POWER PLANT ENGINEERING

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Increased Capacity at Prairie du Sac

TO MEET AN INCREASED DEMAND AND TO INCREASE THE RELIABILITY OF SERVICE THIS PLANT HAS PROVIDED ADDITIONAL GENERATING EQUIPMENT AND BETTER LINE PROTECTION

NOTWITHSTANDING the fact that the power requirements of industry in general have for the past few years been less than normal, the Wisconsin River Power Co. operating hydroelectric plants at Kilbourn and at Prairie du Sac on the Wisconsin River, has experienced a steady increase in load which recently reached a point where it became necessary to install a new and larger unit in the Prairie du Sac plant. This load increase has been due almost entirely to the increased utilization of electrical energy in the home and on the farm. Such general use is now being made of electric washing and ironing machines, vacuum cleaners, and heating appliances such as stoves, toasters, percolators, grills, etc., that the consumption of current for domestic purposes has been vastly increased. These appliances have a load factor all their own which has been studied to determine just when the peaks occur, what factors govern their occurrence and how it may be forecasted.

The Wisconsin River Power Co. was among the first in this country really to make a study of and cater to the farmers' requirements and their efforts along this line have met with gratifying results. This type of retail customer has grown apace and is responsible, in a measure, for the increased demand on the system. The large block consumers such as the Milwaukee Electric Railway & Light Co., and the Madison Gas & Electric Co., require power at a quite constant rate.

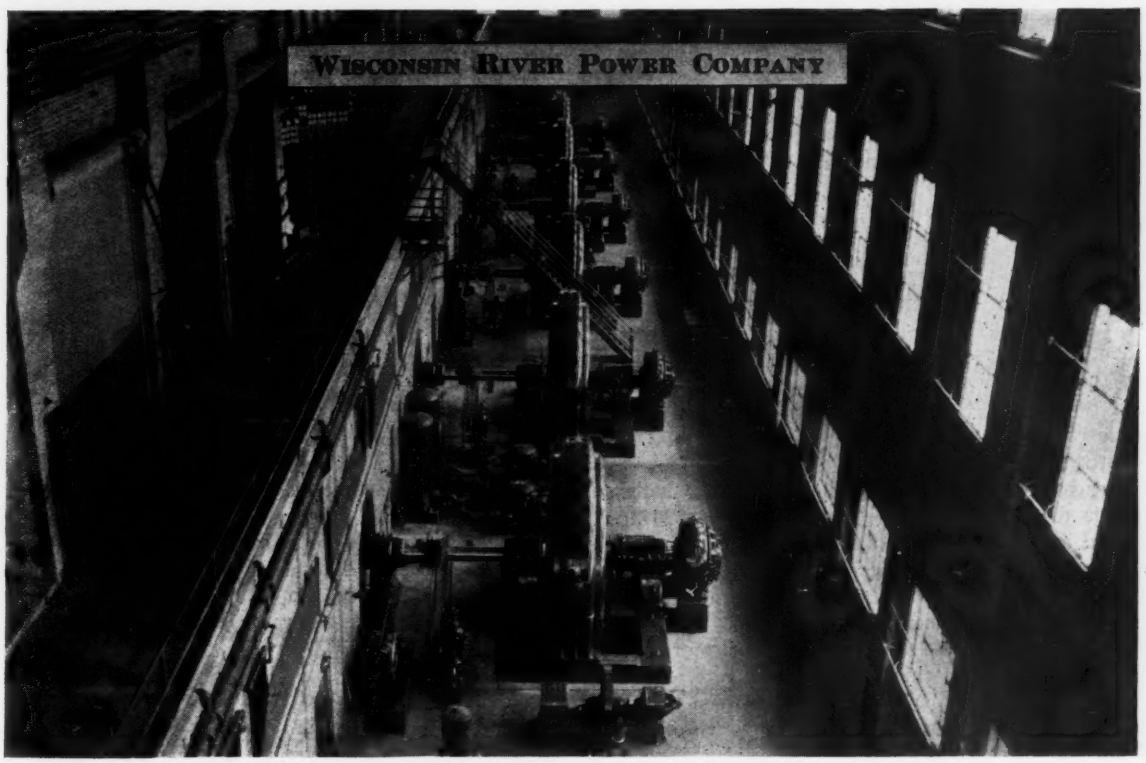


FIG. 1. BIRD'S-EYE VIEW OF THE GENERATOR BAY AT PRAIRIE DU SAC

With the recent addition of larger units, the Prairie du Sac plant is now equipped with eight hydraulic turbine generator sets, Fig. 1, four supplying 25-cycle current for industrial purposes and four generating 60-cycle current, largely for lighting and domestic consumption.

Hydraulic Features

Originally the turbine units were designed for a 28-ft. head but since the plant was built (in 1915) this head has been increased to 34 ft., which is maintained fairly constant throughout the year. The maximum head water elevation allowed by the state is 20 ft. above a certain bench mark datum at the plant. The variation from this level is only a matter of inches. Tail water elevation is figured from another datum 18½ ft. below the first. Normally this level is about 4.5 ft. but in times of high flow, however, the tail water backs up to as much as 10 or 12 ft. During the recent spring floods, with the overflow gates open a sufficient amount to keep the head within the allowable limits, the tail water rose to almost 10 ft., thus reducing the available head to $20 - 10 + 18\frac{1}{2} = 28\frac{1}{2}$ ft., a decrease from normal of 5½ ft.

Mean low flow amounts to about 5000 cu. ft. per sec., which is less than the requirements of the plant at rated capacity, but the storage capacity of the reservoir, formed by the dam, extending back as it does to within 8 mi. of the town of Portage, a distance of about 20 mi., and having an area of about 20 sq. mi. is sufficient to supply the plant with the required amount of water for a number of days without an excessive drop in head. It is only in case of excessive high flow backing up the tail water that the head is materially reduced and the capacity falls off.

The turbine element, consisting in itself of two direct connected, double-runner units, as shown in the plan and section of the plant, Figs. 9 and 10, measures about 56½ ft. from the upstream outboard bearing to the center line of the bearing between it and the generator. These units, made by the Allis-Chalmers Co., are of the horizontal double-runner, inward-flow type. The wheels are 64 in. in diameter by 24 in. wide, giving an inlet area of about 33½ sq. ft. for each runner or 134 sq. ft.

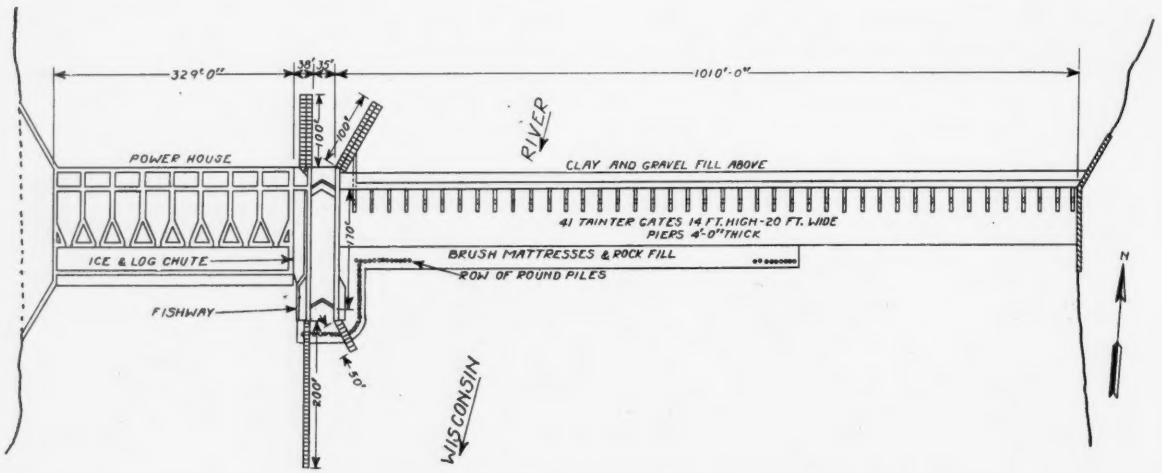


FIG. 2. GENERAL PLAN OF THE DAM AND POWER HOUSE

At the dam site, Figs. 2 and 3, the width of the river is in excess of a quarter of a mile, 1402 ft., to be exact. Of this distance, the power house occupies 329 ft., a log and ice chute and fishway, 28 ft., a lock, 35 ft., and the dam proper, 1010 ft. The crest of this dam is composed of 41 Tainter gates, each 20 ft. wide by 14 ft. deep with 4-ft. abutments between them. Supporting the reinforced concrete shell there is a series of concrete buttresses, one, 4 ft. thick, under each gate abutment, and two, 18 in. thick, spaced equally between the larger ones. The width of the dam at its base between the ends of the concrete work is 98 ft.

On a platform above the gates there is provided a track on which there are two electrically operated, traveling gantry cranes used for lifting the gates. With each gate raised one foot, these gates are capable of wasting about 25,000 cu. ft. per sec., which is about equal to the mean flow. In case of heavy floods the gates may of course be lifted a greater amount to take care of the greater flow.

The discharge throat of each unit has a diameter of 11 ft. and therefore an area of 95 ft. or 190 sq. ft. total.

The turbines are set in an open flume, each of which is provided with three head gates, making up the total width of 37½ ft. Each gate is 10½ ft. wide by 19½ ft. high, so that the total area of the gate opening is about 615 sq. ft. The width of the discharge tunnel, which has an oval section, is 35½ ft. and the depth at the entrance to the tail-race 18¼ ft., giving an area somewhat less than 600 sq. ft.

Generating Equipment

Each turbine unit drives its generator (also an Allis-Chalmers unit) through a 14-in. shaft which projects through the wall of the flume. There are eight of these generators arranged side by side as shown in Fig. 1, which is a bird's-eye view of the generator bay. Units Nos. 5, 6, 7, and 8 located in the east half of the building are 25-cycle machines. They are each rated at 2800 kv.a. at 107 r.p.m. They generate current at 2300 v. 3-phase and at rating deliver 705 amp. per phase.

The system as originally installed, before the addition of the Prairie du Sac plant and when only the Kilbourn plant was considered, was built for 25-cycle operation mainly to supply Milwaukee. As that load increased beyond the potential capacity of Kilbourn this plant was added, and in order to feed into the existing system without having to employ frequency changers, 25-cycle machines were used. As other loads were obtained, 60-cycle machines were installed to meet these needs. The last increase in demand was met by an addition to the 60-cycle generating equipment.

The other four units of the group, Nos. 1, 2, 3, and 4, generate 60-cycle, 3-phase current at 2300 v. One of these units is rated at 3000 kv.a., one at 4200, and two at 4800 kv.a. All run at 120 r.p.m. The 25-cycle units are 28-pole machines and the 60-cycle, 60-pole.

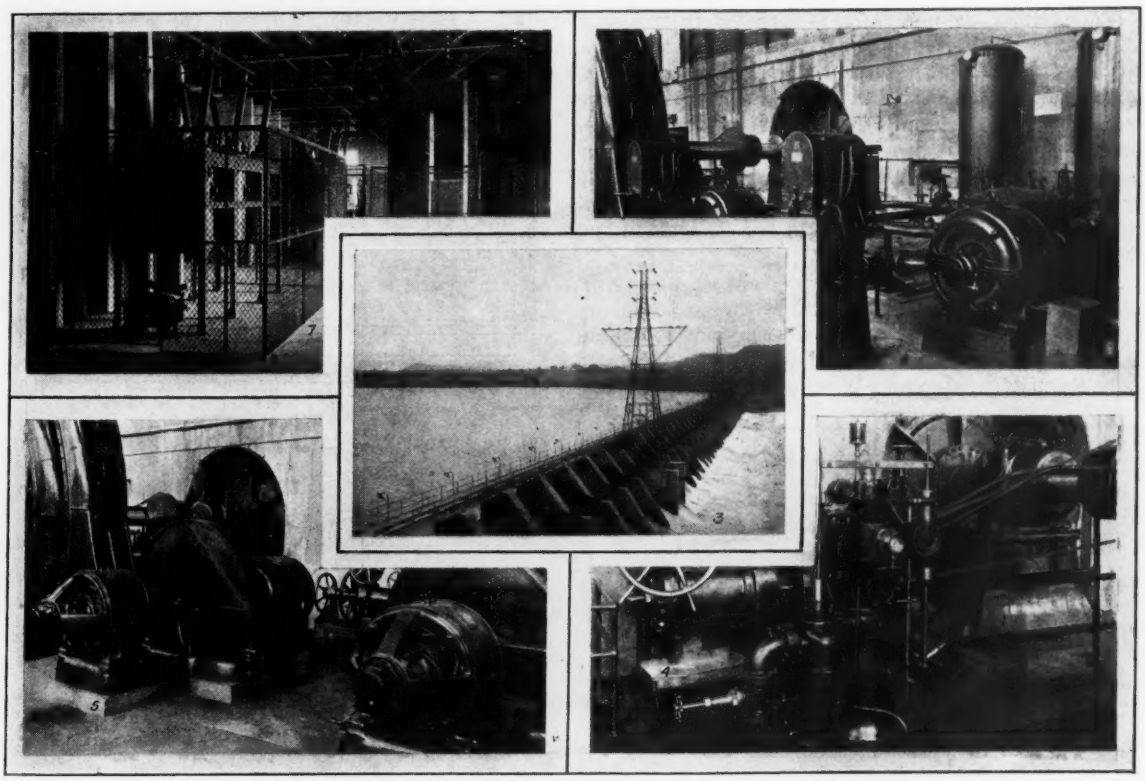


FIG. 3. VIEW OF THE DAM FROM THE POWER HO USE. FIG 4. OIL PRESSURE RELAY GOVERNOR. FIG. 5. FLYWHEEL MOTOR-GENERATOR SET EOR SUPPLYING CONTROL CURRENT. FIG. 6. GEAR PUMPS FOR SUPPLYING OIL TO THE GOVERNOR. FIG. 7. VIEW OF THE HIGH TENSION ROOM

All machines are built with a standard size frame and foundation, the frame diameter being in each case, 17 ft. A view of one of the 25-cycle units is shown in Fig. 11.

Excitation current is supplied in each case by a direct connected, shunt wound generator delivering current at 125 v. The power delivered by these generators amounts to from 1.5 to 2.0 per cent of the output of the main generator.

Each unit is equipped with an Allis-Chalmers oil pressure relay governor size 3, as shown in Fig. 4. Any alteration in speed from normal acts, through flywheel governor weights, to move a pilot valve which admits oil under a pressure of 150 lb. to one end of the main plunger cylinder. At the same time, a release valve is opened on the other end and the plunger moves to adjust the position of the turbine wicket gates to bring the unit back to normal speed. As the plunger moves a compensating link is adjusted to close the pilot valve and thus prevent any overtravel of the main plunger.

All switching and station auxiliary control is accomplished by remote electrical control from a flywheel motor-generator set. Current used for this purpose, then, instead of being taken from the exciter bus is supplied by a General Electric motor generator set provided for this specific purpose. This set shown in Fig. 5, is installed in duplicate so as to minimize as far as possible the liability of a shutdown due to lack of control current. The motor is of the squirrel cage induction type and is rated at 35 hp. It takes 25-cycle current at 220 v. from a transformer provided with the set. The direct connected compound wound generator is rated at 15 kw. and delivers at rating 130 amp. at 115 v. The normal speed is 1500 r.p.m. Between the motor and the generator, there is mounted a rather heavy flywheel for this size unit. By using this heavy wheel, the generator is enabled to supply current for switching control for a considerable length of time after the current to its motor has been for any reason cut off.

Between units 3 and 4 there is a duplicate set of oil pumps for supplying oil for the governor and for lubrication. The pump is an Allis-Chalmers gear type and is direct connected to a 40-hp. 220-v., 720 r.p.m. 60-cycle motor as shown in Fig. 6. Oil is pumped under a pres-

sure of 150 lb. to the tanks shown in the background, from which it is piped direct to each of the governors.

Lubricating arrangement for getting at the submerged and otherwise inaccessible bearings of the turbine consists of a central hand operated grease gun which has an individual pipe line to every greased bearing in the plant. By periodically pushing in the plunger, a shot of grease is fed under a pressure of 200 lb. to any desired bearing. Each line is provided with a stop cock which may be opened so as to feed through that particular line.

Between units 5 and 6 there is a 6 by 6-in. Ingersoll-Rand air compressor which is used to supply air for blowing out the generators and switchboard wiring connections and also for operating pneumatic tools in the repair shop. The unit is belt driven from a 10-hp. 220-v. Fort Wayne Electric Co. induction motor.

Transformer cooling water is supplied from a well by a 3-stage centrifugal pump direct-connected to a 25-cycle, 25-hp. 220-v. induction motor running at 1500 r.p.m. This unit is located at the west end of the power house and takes its supply from a well directly outside. An emergency set is provided to circulate river water in case the main pump fails or well water is unavailable for any reason. This set consists of two Cameron centrifugal pumps direct connected to two 25-cycle, 5-hp., 220-v. 1420 r.p.m. motors.

Electrical Features

All low tension busses, transformers and switching mechanism are located on the first floor, i. e., directly above the turbine flumes. Westinghouse water cooled, oil insulated, transformers, rated at 7500 kw. are used on the 60-cycle system. General Electric transformers of the same general design rated at 2800 kw. are used on the 25-cycle side. Each unit is mounted in a separate compartment provided with a steel curtain as shown to the left in Fig. 1.

The Westinghouse switch and bench boards are located in the center of the balcony. A view of a portion of this equipment is shown in Fig. 12. The switch and instrument board is arranged in a semicircle around the load dispatchers' table in such a way as to make it difficult to obtain a good picture of the system but the accompanying illustration will suffice to indicate the general arrangement. The first panel at the left is for the flywheel motor generator sets; the two solenoid relays at the top are for additional protection to transfer the direct current control system from either motor generator set to the exciter bus in case both units are rendered inoperative.

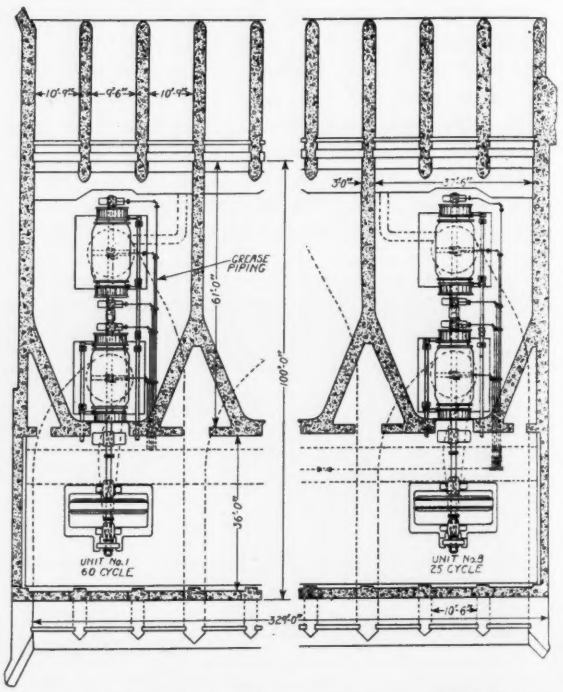


FIG. 9. PLAN VIEW OF THE TURBINE UNITS IN THE STATION

The other panels of this group, constituting half the board are for station auxiliaries; compressor, heating, cooling water pumps, workshop, crane, gantry crane, lock gates, governor oil pumps, Tainter gates, oil dehydrator, and sump pumps.

The remaining panels on the right half of the board are for the various instruments usually found in a power plant. They consist of voltage regulators, volt—and ammeters, indicating and recording watt meters, power factor meters, synchronoscope and frequency meter. The instruments at the left end of this right half are for the 60-cycle machines, Nos. 1, 2, 3, and 4; those on

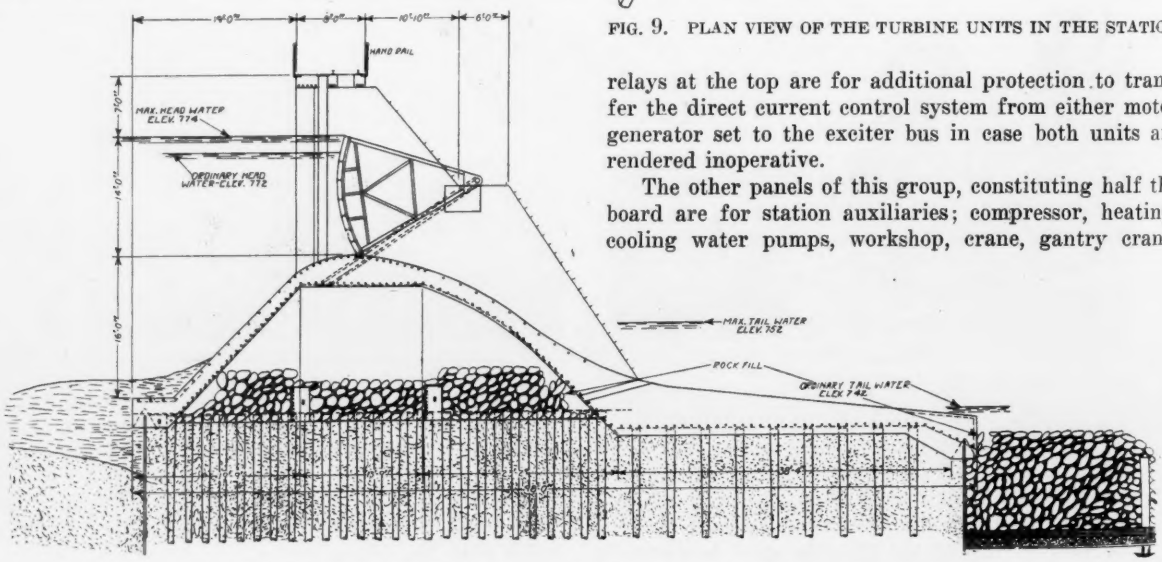


FIG. 8. CROSS SECTION OF THE DAM, SHOWING HOLLOW CONSTRUCTION

the extreme right are for the 25-cycle system. Recording instruments are placed on the back of the board.

The Westinghouse generator voltage regulator on the 60-cycle system which originally contained 24 relays now contains 12 additional units in a separate case to the right of the original regulator installation.

The left center section of the board (not shown in full) containing the 60-cycle instruments is equipped with General Electric Tirrill regulators. The switchboard is a combination of both vertical and bench board types as shown in the illustration.

The bench board in the foreground is for the control of the generating units; the vertical section is for controlling all high and low tension feeders as well as the station auxiliaries. The station has divided its service into three quite distinct classes: (1) the wholesale consumers in Milwaukee and Madison, (2) small towns in the vicinity of the plant, and (3) local farmers' lines. The names on the 60-cycle control switches indicate that current is supplied to the towns of Roxbury, Mazomanie, Sumpter, Sauk City, Prairie du Sac, Mineral Point, Baraboo and Portage besides to the local farmers. All of these towns are located within a radius of about 25 mi. so that the line losses are not excessive. This system serves, in all, something like 95 different communities.

All 2300-v. generator switching equipment is located on the first floor in a bay directly behind the transformers. On the 25-cycle side the switching is accom-

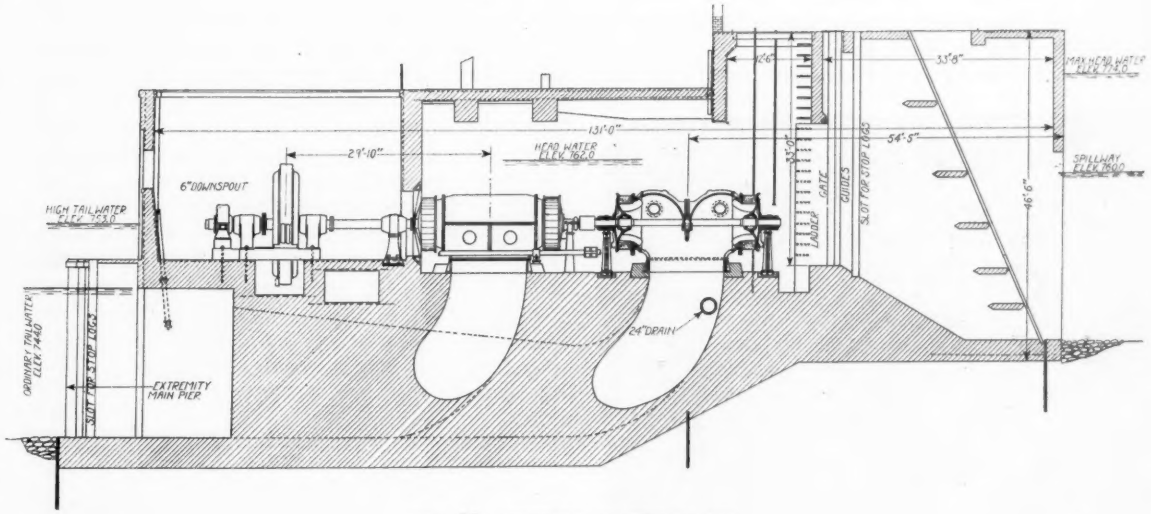


FIG. 10. SECTION OF THE PLANT

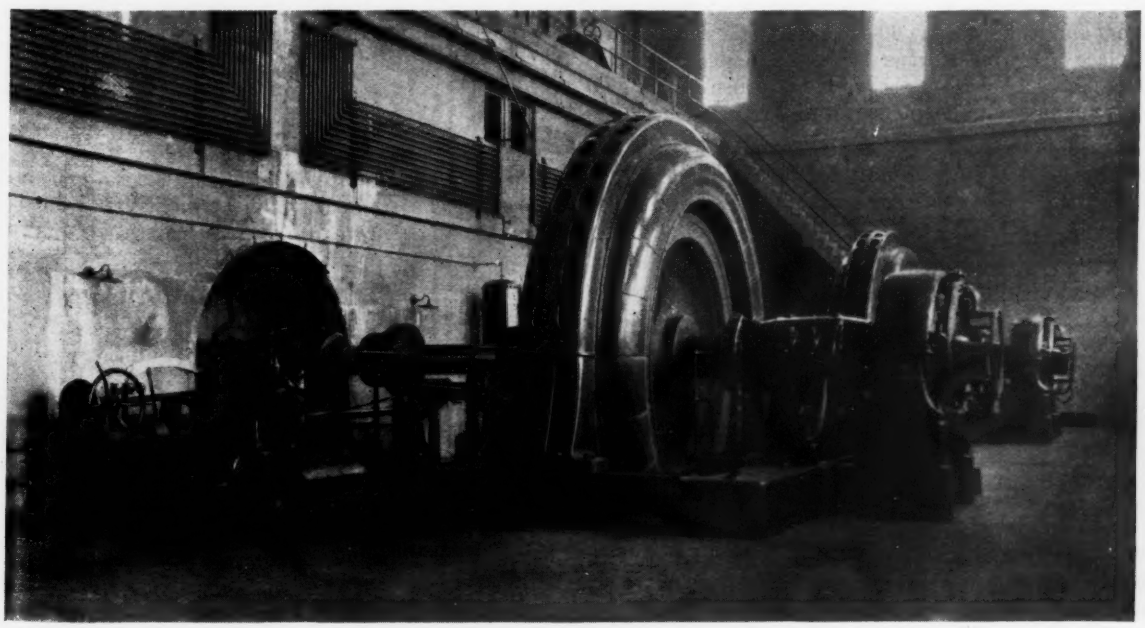


FIG. 11. ONE 25-CYCLE GENERATOR WITH EXCITER AND GOVERNOR

plished by means of a system of Pacific Electric remote controlled oil switches. On the 60-cycle side, Westinghouse oil switches are used throughout.

All 66,000 and 33,000-v. transformer switching is effected on the next floor above with Westinghouse high tension oil switches. Line switches (also of Westinghouse make), disconnects, and instrument transformers are located on the top floor, as is also the Westinghouse 73,500-v. (maximum rated) electrolytic lightning

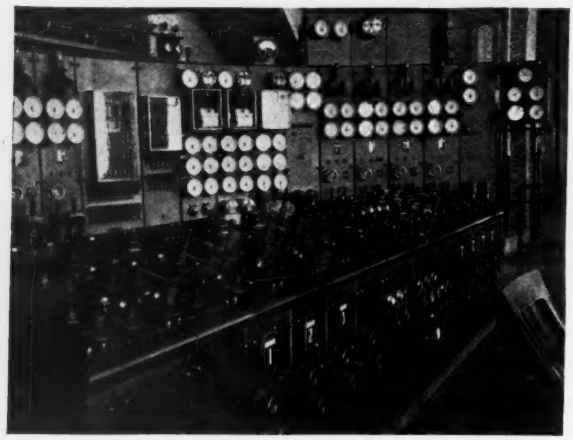


FIG. 12. PARTIAL VIEW OF THE SWITCHBOARD

arresters. A view of a section of this room is shown in Fig. 7.

On the 25-cycle system a bus is provided on the high tension side of the transformers which with the generator bus permits the use of any combination of generators and load. On the 60-cycle side a tie switch takes the place of the transformer bus and a double generator bus is used. Choke coils between the transformers and generator busses are employed to protect the generators

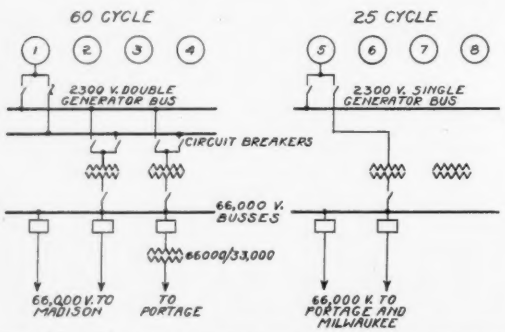


FIG. 13. 60 AND 25-CYCLE PLANT WIRING DIAGRAM

from any line disturbances that might occur. For further protection a system of ground switches is installed between the high tension bus and the transformers. Figure 13 will serve to show diagrammatically the wiring layout on both the 60 and 25-cycle systems.

High tension wiring is carried vertically through concrete shafts from one floor to the other and under the ceiling to a point directly above various switching devices, all of which are located in the middle of the room and are carefully protected by heavy wire screening as a safety precaution.

The high tension transmission circuits, which are in most cases in duplicate, are carried for the most part on 50-ft. steel towers, built by the American Bridge Co., spaced about 600 ft. apart. The two circuits are carried, one on either side of the tower, and are spaced 12 ft. apart, horizontally. Each phase line is spaced 6 ft. vertically from the adjacent one.

In order to give proper relay protection to the interconnected 66,000-v., 25-cycle, parallel line system involving Prairie du Sac and Kilbourn, and generating stations tied in with the Milwaukee Electric Railway & Light system through Watertown and Portage substations, a current balance type of relay which will handle each pair of lines differently is used.

The schematic diagram shown in Fig. 14 will serve to show the nature of the system. It will be noted that the system virtually segregates itself into three sections

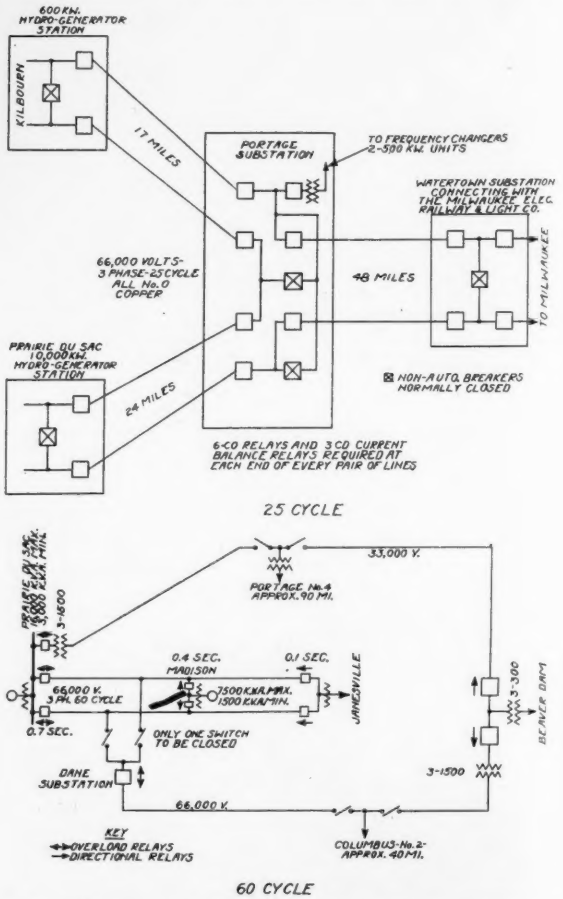


FIG. 14. 60 AND 25-CYCLE DISTRIBUTION SYSTEMS

on the 25-cycle layout, all independent of each other, with energy applied at each end of each section.

Heretofore it has been necessary to use directional relays with potential elements to provide the protection required by such a system as this, but with this type of relay, operating on a current balance principle, it is unnecessary to use directional relays where there is more than a single source of power.

This type "CD" current balance relay, made by the Westinghouse Electric & Manufacturing Co., is of a double contact type, actuated by the difference in current

in any two lines to be differentially protected. The relays automatically close their contracts on either one side or the other depending on which line is in trouble, and trip out the breaker of the defective line, at each end of the line, within the time limit ascribed to the breaker relays according to the time curve shown in Fig. 15. The time curve on each relay is a characteristic curve for what is known as a No. 5 time setting only, which indicates that the relay will operate in a maximum time of ½ sec. to trip the breaker on the defective line when the lowest loaded (good line) is carrying 2000 per cent load, i. e., down on the flat portion of the curve.

With one line out and the other line in service, the line that was out can be thrown in without disturbing the good line for the reason that it takes double current, in a loaded line with no current in unloaded line, to operate the relays. For this reason it is unnecessary to observe any special precaution when putting a line of a pair of lines, back in service. This current balance scheme obviates the necessity of using pilot

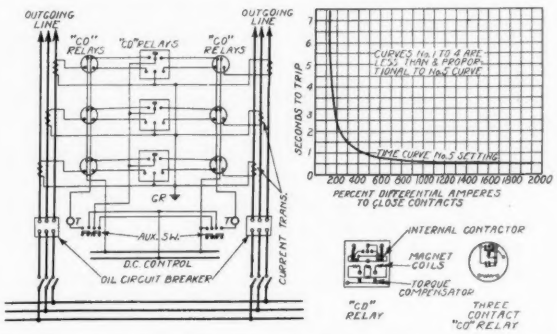


FIG. 15. TIME SETTING CURVE, NO. 5, FOR TYPE C D CURRENT BALANCE RELAY AND WIRING DIAGRAM OF THE RELAY CONNECTIONS

wires to obtain differential transmission line protection.

With circuit breakers of a type capable of opening any short circuit that might occur, such as are used in this installation, it is highly advantageous to get the short off the system as rapidly as possible, not only from the standpoint of any material damage that might result, but also for better protection of service to the general public.

60-Cycle System

EMANATING from Prairie du Sac, as illustrated by Fig. 14 (60-cycle system) there are three high tension transformer lines, two of which are 66,000 and one is 33,000 v., the latter constituting a ring system feeding Columbus, Beaver Dam and Portage.

For successfully relaying a single ring or a pair of transmission lines such as the Madison-Janesville System, a different type of relay is required than is used on the Portage-Watertown System for the reason that there is no opportunity to protect these lines differentially. As a result, it is necessary to utilize directional relays at all sub-stations in conjunction with overload relays at the main feed-in points.

Due to a recent increase in generator capacity at Madison there is contemplated the addition of an interlocking relay at this point to prevent more than one of the high tension oil breakers (at Madison) opening in case of line trouble between Madison and Prairie du Sac.

The relays as shown are installed primarily to take care of Madison as a sub-station and not as a generating station, and have handled the situation satisfactorily with a limited generator capacity at Madison. However, with added generator equipment a new problem is introduced which can be most easily handled with interlocking relays.

We are indebted to Mr. Neff, president of the Wisconsin River Power Co., and to Mr. Green, superintendent of the Prairie du Sac plant, for their co-operation in the preparation of this article and also to C. B. Padon, relay specialist of the Westinghouse Electric & Mfg. Co., for data on the line protection system.

The Trend of Business

FIGURES received by the Department of Commerce up to June 20 indicate revival of business. Iron and steel are showing above the prewar level, building is making new high records, interest rates are decreasing, employment is increasing and prices show an upward trend.

Coal production is low due to the strike and prices of bituminous have increased slightly, but stocks are as yet ample for present needs. Car loadings, except for coal, are increasing steadily.

Pig iron has risen $3 a ton; steel billets, $4.50 a ton; steel beams, 7 per cent; copper, 4 per cent; southern pine lumber, $1.13 per thousand ft.; common red brick, $3.06 per thousand for May prices over April. Price indexes for most commodities show a slight increase for May over April, but are lower than for May, 1921. Exceptions are fuel, which is higher than for May, 1921, and drugs and chemicals, which are lower than for April, 1922.

Bank clearings and savings deposits are on the increase, and business failures on the decrease, while dividend payments, new incorporations and prices on stocks and bonds all show a gain.

All these indications point to better conditions for business and for workers and steady improvement seems in sight unless some abnormal disturbance is introduced.

THE UNITED STATES GOVERNMENT has more than 130,738 students enrolled in the rehabilitation division of the United States Veterans' Bureau, Washington, D. C., through which the Government is training these veterans in a trade, industry, profession, business or in agriculture. The instruction in these vocations is furnished in leading colleges, technical schools, commercial schools as well as in business establishments, shops and on farms. These men are in training in every state in the union and in every large city in the country. In all the large industrial centers these men who have received this intensive training from the Government are available for positions. Every vocation is represented and any employer who needs additional personnel will be furnished such personnel from his vicinity in short time by notifying the Veterans' Bureau. Not only is this personnel trained in the best schools available, but they have also received practical instruction on the job in industrial establishments and in shops. Employers who wish to employ these ex-service men who have been trained and whose ability successfully to carry on in a vocation has been assured by the training given should correspond with the U. S. Veterans' Bureau.

Notes on Economizer Performance

Losses, Methods of Testing, Obtaining Standards and Maintenance. By A. W. Binns

IN THE April, 1919, issue there appeared in these pages an excellent article entitled—"Economizer Practice," written by M. E. Alone. More than any other material ever obtained, this work helped the writer and pointed the way which has been of value to us in our operation. During the years since then, we have studied our economizer operation, maintained careful records and our performance has improved. We hope sincerely that the comments and data coming out of this work, which follows, will be as valuable to someone as Mr. Alone's work was to us.

Method of Approach

The modern commercial economizer is apparently an extremely simple piece of apparatus. Two fluids,

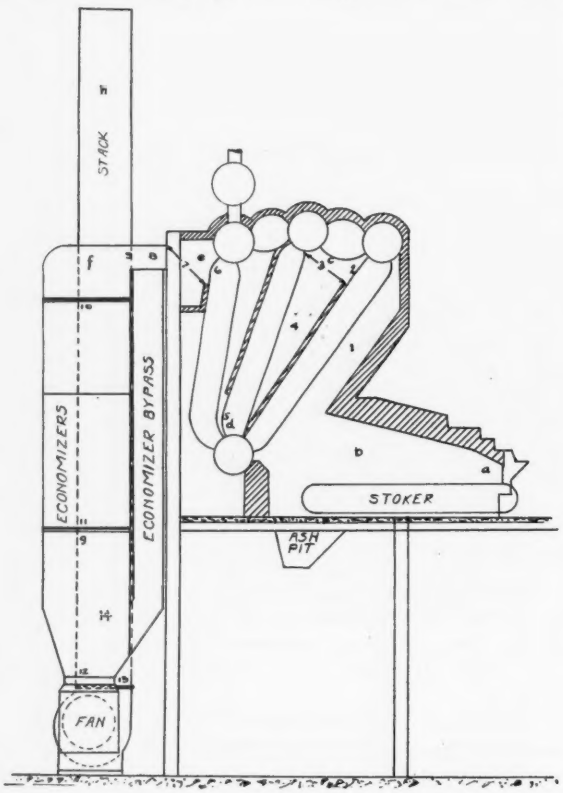


FIG. 1. SECTION THROUGH BOILER AND ECONOMIZER

flowing in opposite directions and isolated from each other by a metallic film, constitute an economizer. One fluid (the boiler exit gas) is at a higher heat level than the other, the water flowing to the boiler, thence a flow of heat from the higher to the lower level takes place and heat is salvaged from the escaping gases, and, to a greater or less degree, the economizer is functioning.

The problem then is simply one of heat transfer between the outgoing gases and the incoming water.

Dimensions of Economizers

The following data applies to the eight economizers on which the work which follows was done:

B. F. Sturtevant Co., builders.
Connected to 1000-hp. Stirling boilers.
Heating surface—4610 sq. ft.
Each—288, 12-ft. pipes—4⅜ in. outside diameter.
Tube wall ⅜ in. thick.
All parts made of cast iron.
Maximum allowable working pressure—300 lb. per sq. in.

Ratio of economizer heating surface to boiler heating surface, 0.455. Economizer is built in two sections, one above the other, the tubes are horizontal. Dust and soot are removed with Vulcan soot blowers. No scrapers are provided. The tubes are in vertical rows; that is, there is no staggering effect.

The general arrangement of economizer with reference to fans and boiler is shown in Fig. 1.

Performance

The efficiency of economizer operation depends upon the following factors, given in the order of their importance.

1. Elimination of air infiltration—setting tight.
2. Tight bypass damper. (See Fig. 1).
3. Elimination of radiation.
4. Cleanliness of inside surface.
5. Cleanliness of outside surface.

Heat balance of economizers. (Poor operating conditions.)

Total heat in gases above outlet water temperature, = 11,700,000 B.t.u. per hr.

Water absorption	= 3,523,500 B.t.u.	= 30.1 per cent
Available heat loss to stack	= 3,965,000 B.t.u.	= 33.9 per cent
Air infiltration loss	=2,495,000 B.t.u.	= 26.7 per cent
Radiation	= 488,000 B.t.u	= 4.8 per cent
Total		95.6 per cent
Unaccounted for		= 4.4 per cent

In the above heat balance, the following conditions existed:

30 lb. of coal per sq. ft. grate surface per hr. used—(262 sq. ft. grate surface on this installation).
15 lb. of flue gas per lb. of coal. (Method of obtaining curve, Fig. 4).
7 lb. of water were evaporated per lb. of coal.

It is apparent that the total heat discharged per hr. may be readily computed:

Let H = Total available heat in flue gas per hr.—B.t.u.
T_1 = Inlet gas temp. to economizer.
T_2 = Outlet gas temp. of economizer.
W = Total lb. per hr. coal burned.
Sp = Specific heat of flue gas = 0.25.
T_3 = Economizer outlet water temp.
T_4 = Boiler room temp.

$$H = 15W(T_1 - T_3)\ Sp.$$

Heat absorbed by water = W × 7 × temperature rise in feed water through the economizer.

Heat lost to stack = $15W\ (T_2 - T_3)\ Sp.$

Heat loss to air infiltration:

CO_2 — Before economizer = 11 per cent.

CO_2 — After economizer = 9.5 per cent.

From Curve Fig 4:

Lb. of gas per lb. coal at 11 per cent = 17.

Lb. of gas per lb. coal at 9.5 per cent = 20.

Therefore for every pound of coal burned 3 lb. of air leak into the economizer, are heated to the discharge temperature of the economizer exit gases and then wasted.

Loss due to air infiltration = $W \times 3\ (T_2 - T_4)$.

Heat loss due to radiation is estimated by assuming a figure of 3.6 B.t.u. per sq. ft. per hr. per degree mean temperature difference was used.

The necessary information is supplied by recording thermometers on the inlet and exit and on the incoming and outgoing water lines.

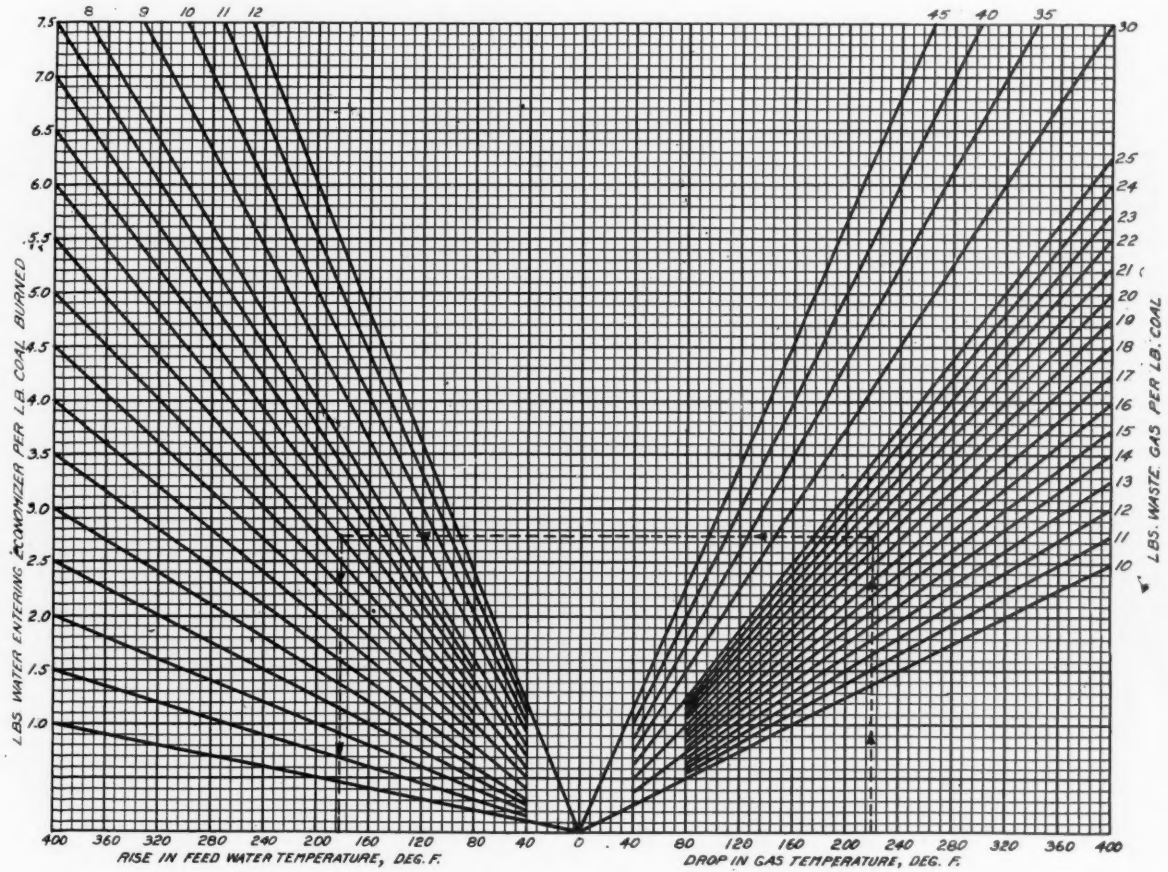

LBS. WATER ENTERING ECONOMIZER PER LB. COAL BURNED
LBS. WASTE GAS PER LB. COAL
RISE IN FEED WATER TEMPERATURE, DEG. F.
DROP IN GAS TEMPERATURE, DEG. F.

FIG. 2. RELATION OF HEAT GIVEN UP BY GASES TO HEAT ABSORBED BY FEED WATER

Checking Performance

In practice it is not desirable to take the time to do much elaborate testing. The following rapid pointers to performance have proven of value to us:

1.—Per cent of possible gas drop.

Theoretically the exit gases should drop to the temperature of the exit water. The actual drop over the possible drop = per cent possible drop.

2.—Heat transfer efficiency.

This figure is the ratio of the heat absorbed by the water to the heat liberated to the economizer from the boiler. This value is read from Fig. 2, being the actual rise over the theoretical as given by the curve.

3.—Sturtevant efficiency.

The Sturtevant Co., through its experience has found that in an economizer, a heat transfer of 4 B.t.u. per sq. ft. heating surface per hour per degree mean temperature difference between the gas and water is in as good a condition as can be expected. Therefore, the actual transfer in any given installation divided by 4 gives the Sturtevant efficiency. This value is struck readily from curve Fig. 3. It has the further advantage that only the load, and water temperature rise need be known. The curve, Fig. 3, is only applicable to the installation in question.

If the preceding three variables are checked from week to week, satisfactory results will be obtained.

Maintenance

Of the losses enumerated, the air infiltration loss is perhaps the easiest to stop and the hardest to keep stopped. It is good practice to have a man inspect the setting daily. There is little or no excuse for holey settings. The best way to get at cracks in the setting is to get into the economizer when it is down and look for streaks of light.

It is our practice to run mechanical cleaners through the tubes once in three months. Care is taken to remove

just as little as possible of the black oxide on the inside of the tube. All the caps must be knocked in. They are all ground joints and must be handled very carefully.

The external heating surfaces were the most difficult problem which we had. The soot blowers were practically useless. No scrapers were provided. A fine dust would form in a wedge shape on top of each tube. Also a fine, hard scale encased each tube. In our installation we overcame much of this trouble by the simple but surprising expedient of hosing down the outside with a gentle stream of cold water. The dust was washed away and the scale seemed to shrink and would fall off upon drying. No injurious effect was noted on the setting, care, of course, being taken to avoid wetting it any more than necessary. This practice raised our heat transfer 10 per cent. Whether this would work on another installation is a question which must be left to him who attempts to apply it, however, I should think that if any considerable sulphur were present, it would be dangerous. In our installation with low grade coal it was a success.

Most or all economizers are provided with an economizer bypass. This bypass has a bad habit of leaking and frequently will jar open. Thus a straight unhindered escape is offered to the exit gases, and they have no hesitation in taking that path. Care should be taken to fasten this damper shut. It is our practice to plaster up the damper with asbestos cement at regular intervals when the boiler is down for cleaning.

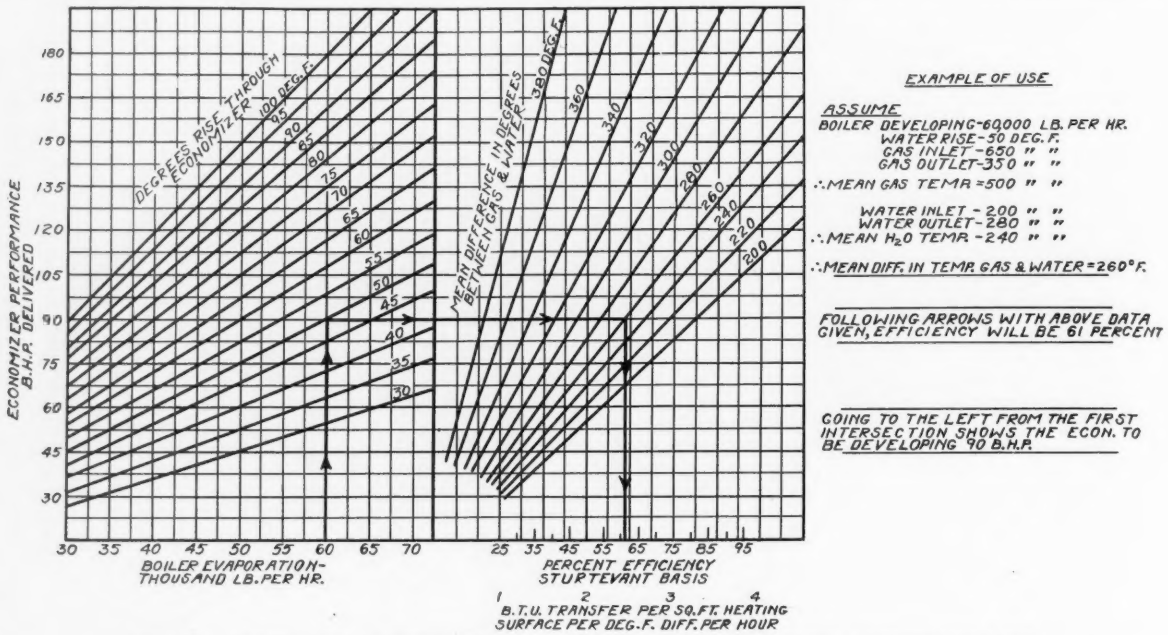

ECONOMIZER PERFORMANCE B.H.P. DELIVERED
DEGREES RISE THROUGH ECONOMIZER
MEAN DIFFERENCE IN DEGREES BETWEEN GAS & WATER
BOILER EVAPORATION-THOUSAND LB. PER HR.
PERCENT EFFICIENCY STURTEVANT BASIS
B.T.U. TRANSFER PER SQ.FT. HEATING SURFACE PER DEG.F. DIFF. PER HOUR
EXAMPLE OF USE
ASSUME
BOILER DEVELOPING-60000 LB. PER HR.
WATER RISE-30 DEG. F.
GAS INLET-650 " "
GAS OUTLET-350 " "
∴MEAN GAS TEMP.=500 " "
WATER INLET-200 " "
WATER OUTLET-280 " "
∴MEAN H2O TEMP.-240 " "
∴MEAN DIFF. IN TEMP. GAS & WATER=260°F.
FOLLOWING ARROWS WITH ABOVE DATA GIVEN, EFFICIENCY WILL BE 61 PERCENT
GOING TO THE LEFT FROM THE FIRST INTERSECTION SHOWS THE ECON. TO BE DEVELOPING 90 B.H.P.

FIG. 3. CHART FOR DETERMINATION OF ECONOMIZER EFFICIENCY—STURTEVANT BASIS

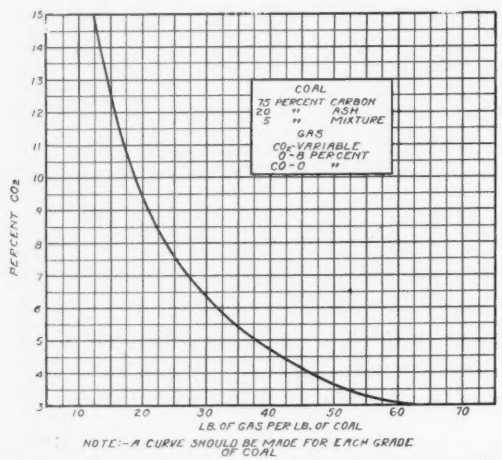


FIG. 4. CURVE USED FOR DETERMINING GAS QUANTITIES

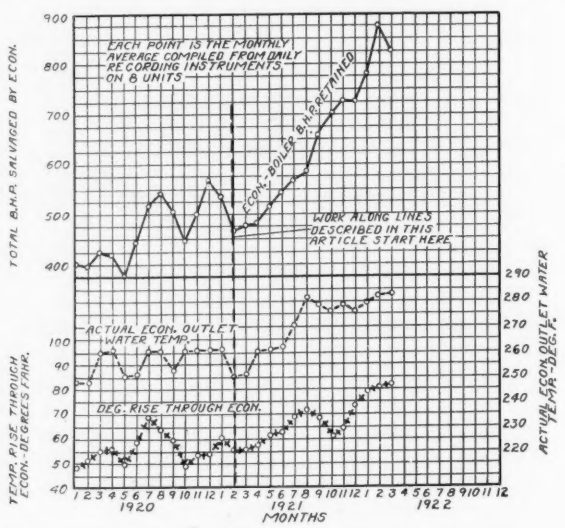

TOTAL B.H.P. SALVAGED BY ECON.
EACH POINT IS THE MONTHLY AVERAGE COMPILED FROM DAILY RECORDING INSTRUMENTS ON 8 UNITS
ECON.-BOILER B.H.P. RETAINED
WORK ALONG LINES DESCRIBED IN THIS ARTICLE START HERE
ACTUAL ECON. OUTLET WATER TEMP.
DEG. RISE THROUGH ECON.
TEMP. RISE THROUGH ECON.-DEGREES FAHR.
ACTUAL ECON. OUTLET WATER TEMP.-DEG. F.
1920
1921
1922
MONTHS

FIG. 5. RECORD OF ECONOMIZER PERFORMANCE

We found radiation to be a very important, and what is more, a controllable factor. The breeching to the economizer was never covered. We covered this about 4 in. deep. We also covered the space on the headers between the tubes with asbestos cement.

In this connection, it should be noted that we have many mechanical difficulties. Occasionally a split tube, or a cracked header will tie us up. We have successfully repaired split headers when the crack is small by putting a soft patch on the outside and plastering Smooth-on on the inside. The Smooth-on is allowed to dry and then baked with a torch.

Cracked tubes where a sand hole has opened up are conveniently and permanently repaired by rolling a 4-in. boiler tube in place in the inside of the defective cast tube.

Small leaks around the caps are easily calked with a chisel. A small cold chisel is held in the hand, no hammer is used, and the ground joint is tapped while the economizer is under pressure. A few light taps will usually stop the leaks.

Altogether the mechanical difficulties are not great and require only the judgment and care ordinarily bestowed on a boiler plant.

Obtainable Standards

Having done all possible to get at the losses enumerated in the methods described, we were able to get the following results, just after going on the line cleaned and with the setting tight:

Inlet Gas	= 620 deg. F.
Outlet Gas	= 410 deg. F.
Gas Drop	= 210 deg. F.
Inlet Water	= 200 deg. F.
Outlet Water	= 300 deg. F.
Water Rise	= 100 deg. F.

Per cent of possible gas drop = 65.

Per cent of heat transfer efficiency = 75 per cent.

B.t.u. per sq. ft. H.S. per hr. per deg. F. temp. difference = 4.1.

Sturtevant efficiency = 100 per cent.

The following figures, taken on economizers in only fair condition, show what may be expected when the utmost vigilance is not exercised:

No. of Econ.	Per cent Possible Gas Drop	Per cent Heat Transfer Efficiency	Sturtevant Efficiency
1	66	54	54
2	62.5	63	72
3	63.6	77	77
4	57	86	93
5	50	79	84
6	60	62	75

The average economizer performance is indicated in curve, Fig. 4. The foregoing figures are probably more nearly what may be expected. That is a gain in temperature of 75 to 80 deg. may be expected when feeding an economizer from an open feed water heater and working at 175 lb. pressure.

Costs

Every man who is familiar with power plant work will say, "Yes, you are saving heat there, but what does it cost you?"

That, of course, is the vital question.

Allowing 15 per cent fixed charges — cost per horsepower day reclaimed (Horsepower = 33,400 B.t.u.)	= 4.00 ct.
Economizer repair cost	= 1.00 ct.
Steam costs for fan equipment	= 1.25
Repair and maintenance costs on fan equipment	= 1.75
Total cost	8.00 ct.

Assuming that the heat in the stack gas at the last pass would otherwise be lost, the economizer places heat in the steam at about 25 per cent of the cost to do it in the boiler.

Notes from Report of Prime Movers Committee of N.E.L.A.

A Resume of Development in Power Plant Engineering During the Past Year

NO NEW development or radical changes in the present design and construction of steam turbines have been reported during the past year, the manufacturers having concentrated their efforts upon further improvements tending to increase both the reliability of service and the efficiency of the unit. No increase in the maximum size of units or of steam pressure and temperature is noted.

The results of an exhaustive survey made of the records of performance of actual operation of large units installed in 27 large central stations, indicate that considerable work of improvement remains to be done to safeguard successfully the reliability of operation of turbo-generators, in order to secure the maximum degree of commercial service from these units.

Condensing Equipment

As a rule, the entering end of a condenser tube becomes worn out while the rest of the tube is still in good condition. While reversing the tube will double its life, it is considered an unsatisfactory expedient and other methods are sought for. The use of paint or varnish to coat the first few inches of tube has given some satisfaction in reducing this end erosion. Another method proposed is to insert a liner, either cylindrical or nozzle-shaped, two or three inches long, in the entering end. At the new Dalmarnock Station at Glasgow, a new type of ferrule has been installed. This ferrule is several inches long, being extended into the water head of the condenser. Its purpose is to form a cheaply renewable entering end of the tube to take the wear and deliver the water to the tube itself in a properly stream-lined flow.

Internal heater sections in condensers for heating feed water do not seem to be warranted now, since other methods of heating feed water by bleeding steam from lower stages in the turbine, have proved quite successful.

Considerable progress has been made in methods of cleaning condensers without removing the units from service. Reports from various plants in which tube cleaners have been installed are favorable, and it seems to be generally conceded that the tube cleaners are of great service. One of these plants reports that as soon as the vacuum drops, the hydraulic jets are put in

operation, stirring up the refuse in the tubes, and the vacuum is promptly restored.

The use of compartment condensers is another solution of the problem. Which of these two methods would be the best in any particular installation depends upon the character and nature of the materials deposited in the condenser. The tube cleaner is easier to operate, but in some installations is not effective in removing the slime which collects on the tubes.

Boilers, Superheaters and Economizers

There is a continued tendency toward the use of boiler steam pressures up to 350 lb. gage and 700 deg. F.

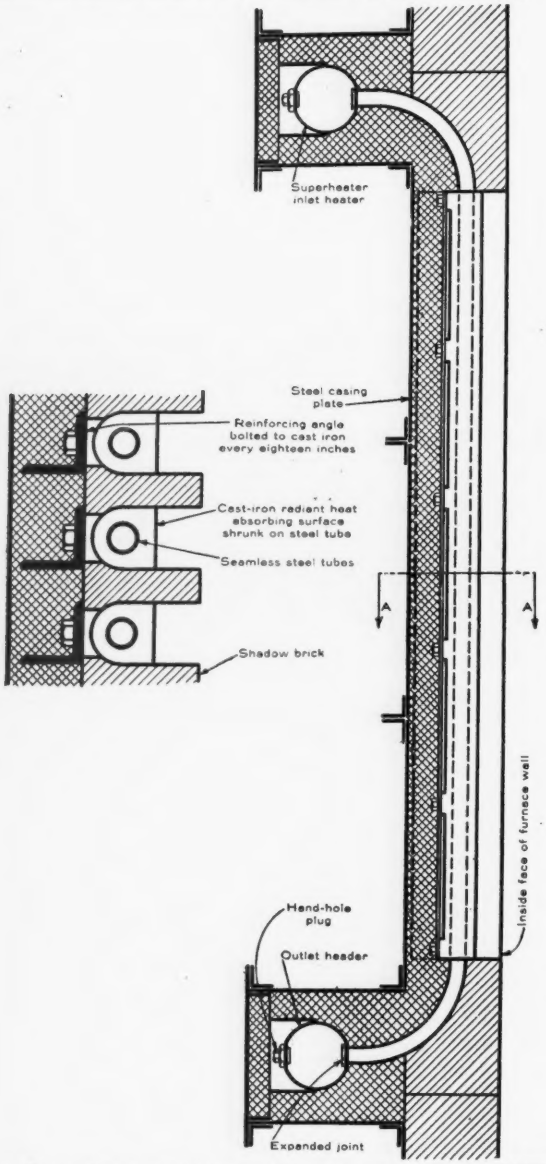


FIG. 1. FOSTER RADIANT HEAT ABSORBING SUPERHEATER ELEMENT

total temperature. A summary of operating conditions of 40 stations indicates that the majority are designed for the pressure range of 250 lb. to 270 lb. gage.

The economical value of mechanical soot blowers over the periodical hand cleaning or the use of the hand steam lance has been questioned. This appears to be largely a problem of local conditions, as the prime purpose of soot blowing is to increase the length of time a boiler may be kept in service without appreciable loss in capacity or efficiency.

The rate at which soot collects depends on a number of factors, such as the kind of fuel used, the methods of firing, size of combustion space, etc.

In the case of low boiler settings, long flaming fuel with tarry constituents, or horizontal systems of baffling, mechanical soot blowing systems will undoubtedly prove desirable. In many instances the deciding factor may be the resulting reduction in the number of operating men required.

However, as the size and the height of the combustion chambers in modern boiler settings are increased, allowing complete combustion of the fuel to take place before the gases strike any part of the relatively colder boiler surfaces, it is not improbable that soot blowing may be reduced to a minimum under normal operating conditions.

With the increased use of the higher steam temperatures, it is becoming more evident that variations in temperature due to operating conditions, should be avoided as much as possible. This calls for more care in the design and location of the superheater, as well as in the operation of the entire boiler unit. It has been suggested that for final steam temperatures much in excess of 600 deg. it will mean adopting superheaters for absorbing of radiant heat rather than the location merely for the absorption of the heat by travel of the gases over the heating surface.

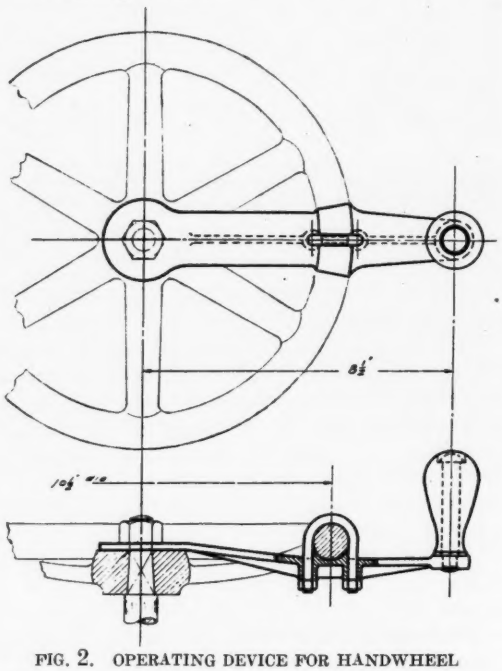


FIG. 2. OPERATING DEVICE FOR HANDWHEEL

A superheater of this type, made by the Power Specialty Co. is shown in Fig. 1. Extensive tests have been conducted on superheaters of this type, located in the rear wall of the combustion chamber directly facing a Taylor stoker under a 600-hp. water tube boiler. Results indicate that with this type of super-

heater, as boiler rating increases, superheat will slowly increase to a maximum of 150 to 200 per cent of rating. Above that point, superheat will slowly decrease as rating increases. This heater, known as the Foster R H A Superheating Element, is designed to utilize heat radiated from the furnace. Ordinary forms of superheater construction cannot do this, because the rate of heat transfer would be too high. An element completely surrounded by furnace gases would require prohibitive pressure losses for steam cooling to prevent overheating, twisting and distortion followed by failure, due to burning out or strains.

In the Foster R H A Superheater Element, the seamless steel tube is fitted with solid cast iron rings, the gills of which are squared on one side instead of circular. The flat side only is exposed to the furnace, the heater being built in and forming a part of one or more of the furnace walls. At suitable intervals the cast iron rings are anchored to heavy structural members to resist distortion. A casing is built in back of the R H A elements, and the space between is filled with insulating material.

The obvious advantage of this superheater is that it utilizes efficiently radiant heat that is often the cause of high maintenance costs for furnace brickwork.

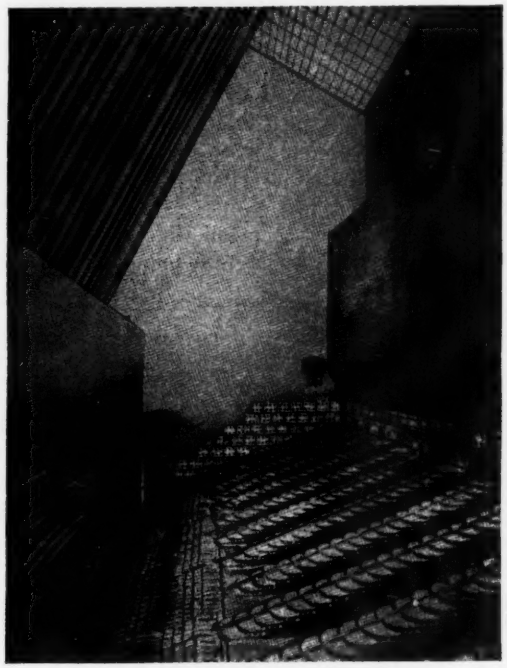


FIG. 3. PERFORATED BLOCKS IN THE HARTFORD ELECTRIC CO. FURNACE

In view of the increasing tendency to operate boilers at higher sustained ratings, it is evident that more attention must be paid to the baffling of boilers; and there is a preference in the use of inclined baffle walls.

While no basic changes in the design of feed water regulators have been made during the year, the question of feed water regulation is being studied in more detail by all operators, as affecting not only the steaming of the boiler but the superheat. Considerable work remains to be done in this line of development to meet satisfactorily the requirements of operation.

No unusual troubles have been reported with blowoff or safety valves and improvements made in equipment have been mostly confined to details of construction. Operating engineers may be interested in the operating device for handwheels on valves shown in Fig. 2. Although ridiculously simple, it facilitates opening and closing the valve and many operators feel that it is an advantage. It is supplied by the Yarnall-Waring Co.

With reference to the external cleaning of soot from cast-iron economizer tubes, opinions vary greatly as to the relative advantages of scrapers or mechanical soot blowers. The consensus of opinion seems to be stronger in favor of the use of mechanical soot blowers rather than scrapers, for the reason that the use of scrapers requires a large number of openings in the top of the economizer which allow large quantities of excess cold air to enter the casing, particularly where induced draft is used for the higher ratings. It is also felt that the ironing action of the scraper packs on the surfaces of the tubes a compact sort of deposit, which forms a very good heat insulator.

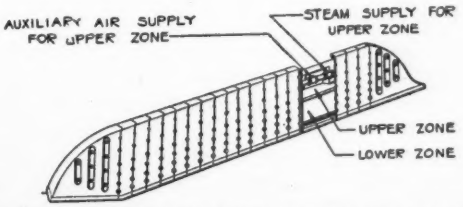


FIG. 4. CAST IRON SIDE WALL AIR BLOCKS, FURNACE ENGINEERING CO.

Several members advise that they have tried washing the external surfaces of both economizers and boilers, and find that no undesirable results occurred, provided the wetted surfaces are dried quickly and adequately.

Two committee members having mechanical soot blowing systems on economizers with different arrangements of cleaner elements, one type blowing at right angles to the flow of gases, and the other type blowing parallel and in the direction of the gas flow, report that better results are obtained with the type blowing in the direction of the gas flow.

Stoking Equipment and Furnaces

Under the subject of stoking equipment and furnaces the various methods developed to prevent clinker formation to brickwork are interesting.

Perforated firebrick blocks located along the clinker line of forced draft stokers through which air is blown from the stoker air duct, is the most popular means for preventing clinker adhesion. The results generally obtained from the use of these blocks have been satisfactory.

In a number of installations the mistake has been made of carrying these blocks too high above the grates, resulting in a decided increase in excess air and with consequent loss in efficiency.

The Bernitz system, which consists of leaving openings between adjacent bricks in the clinker zone, is in satisfactory use in several plants.

Perforated cast iron side wall air boxes are giving very satisfactory results on underfeed stokers in quite a number of plants. Most of the stoker manufacturers are prepared to supply apparatus of this character. The

type manufactured by the Furnace Engineering Co. is shown in Fig. 4.

H. F. Eddy, of the Consumers Power Co., has developed a very interesting attachment improving the operation of clinker grinders. This arrangement is shown in Fig. 5, and we quote his description as follows:

"We use a pine wooden lath with a hook clamped to its inner end. There is a chain attached to the hook

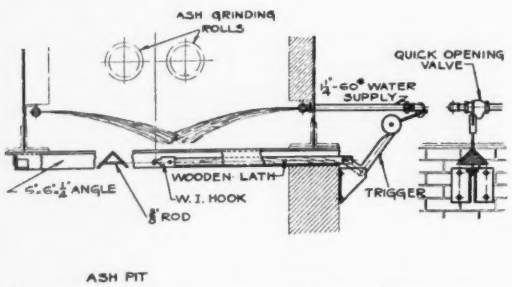


FIG. 5. AUTOMATIC CONTROL OF SPRAY UNDER CLINKER GRINDERS

so that it will not get lost in the ashes in case the lath burns out. The water piping is of a size such that 60 lb. pressure will discharge water into the ash pits at the rate of approximately one barrel per minute. We are operating very successfully without spraying the ashes, which we handle dry in a chain drag conveyor. We have had no clinker grinder burnouts or failures of any sort as a result of overheating."

Air Heaters

THE INCREASING cost of fuel within recent years has awakened considerable interest in air heaters as a means of increasing boiler efficiency. In this country, however, there is no information available on any commercial installation of stationary boilers. Air heaters have been used on boilers in England and the continent for the past 80 yr., having been installed on nearly 30,000,000 hp. In spite of the large number of installations of this apparatus, there is a surprising lack of information relative to their performance. The most reliable data on foreign installations available is given in a paper by W. H. Patchell at the Summer conference of the Institution of Mechanical Engineers on Thermal Efficiency from which Table I has been taken. The results of a number of tests on Howden and Foster air heaters made by the U. S. Shipping Board are given in Table II. The construction of the Foster heater is shown in Fig. 6.

Power Station Auxiliaries

GREAT INTEREST has been displayed during the past year in the subject of heat balance. The method of obtaining heat balance is governed by the size of station and load factor, as well as by means by which the steam to heat the feed water is obtained. The smaller stations and those whose load factors are comparatively low warrant less investment and consequently simpler systems.

The house turbine as a source of auxiliary power and all steam for feed heat has gained in favor. They have been used (1) in conjunction with other steam driven auxiliaries, (2) when all the auxiliaries are electrically driven from the house turbine with an emergency supply available from the main units, and (3) where current for part of the auxiliary power is furnished by the main units. In the latter case, part of the steam for feed heating is bled from the main unit.

The curve shown in Fig. 7 submitted by one company is of interest as showing the analysis of the heat balance as applied to the newer portions of this station.

The abscissae represent the temperature of the feed water between the barometric heater and the economizers, while the ordinates represent the saving of heat input by the boilers and superheaters per kilowatt output of the main unit over the conditions of no feed water heating by steam.

As basic conditions, the following were taken: the steam supplied to the boiler feed pumps, which are all steam driven, and the power required to operate the economizers are not deducted from the savings; the condensate is assumed to go from the main condenser to the heater at 80 deg. F. The point corresponding to 132 deg. water temperature from which the four curves start corresponds to the temperature at which the feed water leaves the heater after condensing the exhaust from the boiler feed pumps only.

TABLE I. TESTS OF AIR HEATERS (MADE PROBABLY IN 1912)

No.	Date	Hours Duration	PLACE	Type of Boiler	Heating Surface of Boiler	Grate Area	Type of Stoker	Type of Air Heater	Heating Surface of Air Heater	Pounds of Coal per Square Foot of Grate Area per Hour	Coal Burnt per Hour	Ratio of Air Heating Surface to Coal Burnt per Hour	Temp. of Gases		Temp. of Air		Rise in Temperature of Air	Excess of Air Over That Necessary	Extra Efficiency* of Boiler Directly Due to Air Heater	Efficiency of Boiler and Air Heater	Efficiency of Air Heater	B.t.u. Transfer per Sq. Ft. per Degree Diff. per Hour
													Leaving Boiler	Leaving Heater	Entering Air Heater	Entering Furnace						
					Sq. ft.	Sq. ft.		•	Sq. ft.		Lbs.		Deg. Fahr.	Deg. Fahr.	Deg. Fahr.	Deg. Fahr.	Deg. Fahr.	Per cent	Per cent	Per cent	Per cent	Per cent
1	4-8-98	7	Lambeth	Brown's Marine	975	34.0	Hand-fired induced draught	Ellis and Eaves	900	41.0	1,405	0.64	. .	460	118	295	177	110	..	74.0	..	...
2	5-8-98	4	Lambeth	Brown's Marine	975	34.0	Hand-fired induced draught	Ellis and Eaves	900	50.0	1,702	0.53	...	442	112	303	191	117	...	60.0	..	....
3	28-1-14	4	Portsmouth Dockyard	Stirling	3,660	65.7	Underfeed traveling	Usco	1,800	30.5	2,000	0.90	526	374	68	197	129	28	3.1	85.3+	79	1.35
4	29-1-14	4	Portsmouth Dockyard	Stirling	3,660	65.7	Underfeed traveling	Usco	1,800	33.0	2,150	0.84	564	385	71	202	131	61	4.0	83.6+	69	1.63
5	26-9-13	4	Hammersmith	Stirling	6,203	99.0	Underfeed traveling	Usco	2,204	35.5	3,528	0.62	588	383	92	247	155	47	4.2	83.3+	71	2.64
6	16-1-12	6	Davenport Dockyard	Woodeson	4,100	77.0	Class "E" underfeed	Usco	2,378	31.0	2,414	0.98	525	...	79	225	146	54	4.2	82.1+	..	...
7	17-1-12	4	Davenport Dockyard	Woodeson	4,100	77.0	Class "E" underfeed	Usco	2,378	42.5	3,275	0.73	591	402	77	230	153	36	3.9	80.5+	76	1.77
8	18-1-12	6	Davenport Dockyard	Woodeson	4,100	77.0	Class "E" underfeed	Usco	2,378	31.0	2,400	0.99	584	...	88	259	171	69	5.4	80.4+	..	..
9	19-1-12	4	Davenport Dockyard	Woodeson	4,100	77.0	Class "E" underfeed	Usco	2,378	41.0	3,175	0.75	648	...	88	272	184	54	5.3	79.5+	.	..
10	5-2-01	13	S.S. Saxonia (average of 9 boilers)	Marine	2,867	63.3	Hand-fired forced draught	Howden	766	20.5	1,303	0.65	491	396	85	185	100	106	..	82.3	..	3.08
11	21-1-21	8	Michel and Chappet Clichy	Belleville	825	38.5	Hand-fired forced draught	Thermix	755	15.0	585	1.29	572/608	428/471	55	194	138	89	4.7	69.2+	..	1.28

* These "Extra efficiencies" only take into account the thermal units returned to the furnace with the air. + These efficiencies include superheaters.

The straight line marked "Economizer and Heater" represents the gross gain without deduction for the extra steam required from the boilers in order to obtain low pressure steam for heating in the heater over the steam required in the main unit to supply power for the electric auxiliaries.

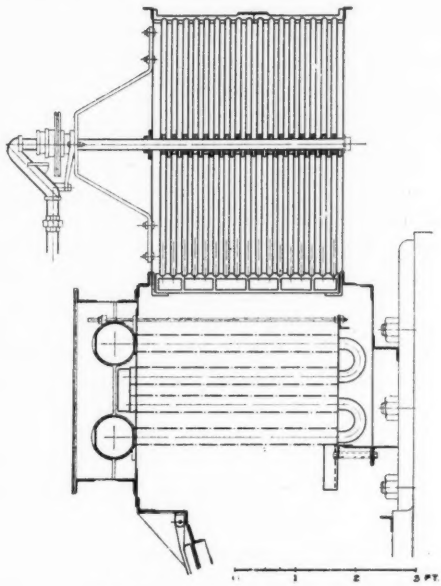


FIG. 6. FOSTER AIR HEATER

The curve at the lower left-hand corner marked "Economizer" represents the heat actually put into the feed water by the economizer at the different inlet temperatures. The two curves, 14th and 13th stage, represent the net gain when bleeding from these stages of the main unit, after deducting the extra steam required by the main unit when bleeding from the lower stages.

The curve marked "Power Set" shows the net gain in heater and economizer after deducting the difference in heat used by the steam power set and that required by the main unit for driving the motor generator set.

Coal and Ash Handling

Of interest in the matter of coal and ash handling is the recent installation of the "Bradford" breaker and coal cleaner at the Calumet Station in Chicago. This machine was designed to take hard run of mine Illinois coal and reduce it to pass 1½ in. screen plate perforations at the rate of 200 T. per hr. It is especially equipped to break up the heavy lumps and to remove the tramp iron, hard rocks and other foreign material. (This breaker was fully described in the May 15 issue.)

Another installation of interest is the submerged ash pit installed at the Springdale station of the West Penn Power Co., shown in Fig. 8.

In installations of this character where ashes are dumped hot in relatively large quantities, adequate precautions must be taken so that damage cannot result from the excessive production of steam, or from gas in the ash pit.

A test of the storage capacity of the ash pits shows that the boilers can be operated at 200 per cent rating for 3½ days before it becomes necessary to clean the pits. The buckets can be operated at about 40 lifts per hr., making it possible for one man to load with ease in less than two hours the day's ashes from a 20,000-kw. unit.

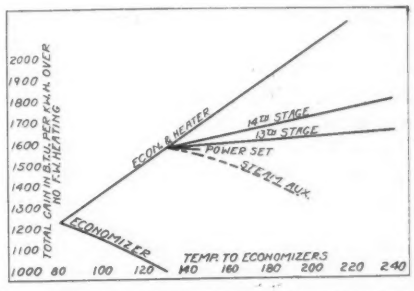


FIG. 7. EFFECT OF FEED WATER HEATING ON ECONOMY

TABLE II. COMPARATIVE TESTS OF HOWDEN AND FOSTER AIR HEATERS

No.	Date	Hours Duration	Type of Boiler	Heating Surface of Boiler	Grate Area	Type of Stoker	Type of Air Heater	Heating Surface of Air Heater	Pounds of Coal per Square Foot of Grate Area per Hour	Coal Burnt per Hour	Ratio of Air Heating Surface to Coal Burnt per Hour	Temp. of Gases		Temp. of Air		Rise in Temperature of Air	Excess of Air Over That Necessary, %	% of B.t.u. in Coal Absorbed by Air Heater	Draft, Difference Through Air Heater, Inches of Water	B.t.u. Transfer per Sq. Ft. per Degree Difference per Hour
												Leaving Superheater	Leaving Heater	Entering Heater	Entering Furnace					
1	9–15–20	9.083	Scotch Marine	3,000	61.8	Hand	Howden	812	12.6	779	1.04	394	290	78	183	101	55.8	3.1	...	1.82
2	9–17–20	10.167	Scotch Marine	3,000	61.8	Hand	Howden	812	19.1	1,185	.68	417	338	78	182	104	48.5	2.7	.043	2.20
3	9–18–20	6.083	Scotch Marine	3,000	61.8	Hand	Howden	812	30.3	1,870	.43	500	428	82	183	101	65.0	3.2	.07	2.81
4	9–20–20	8.00	Scotch Marine	3,000	61.8	Hand	Howden	812	26.4	1,637	.49	520	406	73	175	102	56.5	2.9	....	2.16
5	9–21–20	10.083	Scotch Marine	3,000	61.8	Hand	Howden	812	13.4	833	.97	376	295	74	182	108	41.0	2.7	....	1.83
6	9–22–20	5.00	Scotch Marine	3,000	61.8	Hand	Howden	812	24.5	1,518	.53	581	455	78	212	134	60.6	3.9	.06	2.61
7	9–22–20	5.00	Scotch Marine	3,000	61.8	Hand	Howden	812	19.4	1,200	.67	454	416	79	213	134	44.0	3.5	.03	2.39
8	9–29–20	8.083	Scotch Marine	3,000	61.8	Hand	Foster	1,513	25.0	1,550	.97	469	361	84	218	134	38.6	3.3	.03	1.75
9	9–30–20	10.00	Scotch Marine	3,000	61.8	Hand	Foster	1,513	19.4	1,200	1.26	444	349	73	211	138	41.0	3.5	.04	1.47
10	10– 1–20	12.00	Scotch Marine	3,000	61.8	Hand	Foster	1,513	13.1	808	1.87	373	278	68	210	142	49.8	3.8	.05	1.47
11	10– 2–20	6.083	Scotch Marine	3,000	61.8	Hand	Foster	1,513	30.9	1,910	.79	508	395	67	217	150	43.2	3.9	.01	2.13
12	10– 4–20	8.00	Scotch Marine	3,000	61.8	Hand	Foster	1,513	26.7	1,650	.93	510	387	77	221	144	58.3	4.1	.02	2.02
13	10– 5–20	7.00	Scotch Marine	3,000	61.8	Hand	Foster	1,513	20.4	1,264	1.19	548	407	73	251	178	60.6	5.1	.01	1.84
14	10– 6–20	8.00	Scotch Marine	3,000	61.8	Hand	Foster	1,513	25.0	1,550	.97	581	430	69	245	176	62.4	5.1	.03	2.02
15	10– 8–20	7.916	Scotch Marine	3,000	61.8	Hand	Foster	1,513	20.0	1,238	1.22	528	390	76	242	166	60.7	4.7	.01	1.76
17	10–11–20	7.00	Scotch Marine	3,000	61.8	Hand	Foster	1,513	25.5	1,577	.96	611	452	74	253	179	59.8	5.1	.01	1.96

Treatment of Feed Water

Treatment of feed water is becoming one of the important problems confronting the operation of large power plants. Reagents or compounds which at first were used do not seem to fulfill the requirements of high rating boiler operation. Chemical treatment in water-softening plants has considerably improved the situation; however, the complete removal of all scale-forming solids from the water led to experiments and use of evaporators.

It soon developed that notwithstanding the improvement in quality of the water obtained by the use of evaporators, other factors had to be considered, especially in the case of plants equipped with steel tube economizers where corrosive action was noticed; investigation indicated that the cause of corrosion was due to the presence of gases, principally oxygen dissolved in the water, and extensive developments for their removal proceeded along various lines. The following methods are now in use to eliminate or minimize this source of trouble.

Maintaining temperature of open feed water heaters at atmospheric pressure at 205 to 210 deg. F. will reduce corrosive gases to such an extent that corrosion will be negligible (New York Edison)-(Philadelphia Electric).

The addition of caustic soda to the feed water has been found to eliminate corrosion in one plant (Philadelphia Electric). Two plants are passing feed water over steel placed in the heaters, so that the corrosive gases will attack the metal which is readily replaceable and inexpensive. One plant (Consumers Power Co., Jackson, Mich.) uses reinforcing bars and the other

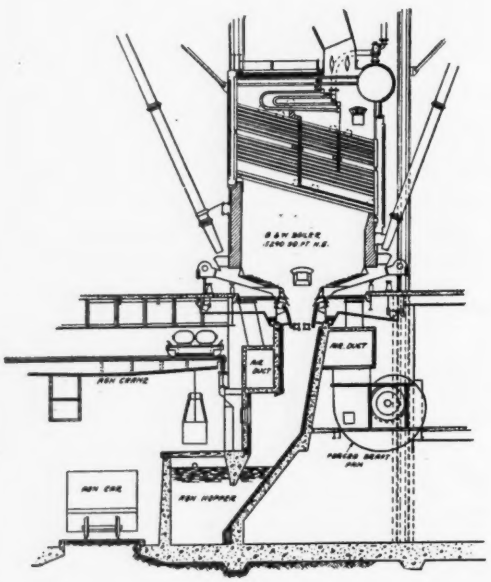


FIG. 8. SUBMERGED ASH HOPPER OF THE WEST PENN POWER CO.

(Union Electric Light & Power Co., St. Louis) uses turnings, and both report favorable results.

Another plant (Boston Edison) puts feed water and exhaust steam from auxiliaries through a jet condenser in which the absolute pressure is kept as close as possible to the saturation pressure, corresponding to the temperature of discharge by means of an air pump.

An interesting case of boiler pitting is reported by one plant (Buffalo General Electric Co.), which uses distilled water for make-up. Pitting was noticed in two boilers which had been idle for five or six months. An investigation indicated that when a boiler stood idle it absorbed oxygen quite readily, and in 10 days was within 22 per cent of the saturation point. As a result, it was decided that: When a boiler was to be idle for any time to fill it to the vent to prevent absorption of air. When this was done, no additional signs of pitting were found.

In connection with the practice of passing feed water over an oxidable material, such as the reinforcing bars or turnings, mentioned above, Paul Kestner, of Paris, in a paper on "Degassing and Purification of Boiler Feed Water," presented before the Institution of Mechanical Engineers, in London, calls attention to the catalytic action of manganese as follows:

"Practice shows that very impure iron rusts very rapidly. Laboratory experiments have enabled the author to find a catalytic agent of great importance, namely, manganese. The presence of manganese hastens the oxidation of the metal; nevertheless, if this action shows itself in the case of small percentages corresponding to the manganese steels, it is not so well marked in the case of higher percentages. A metal which is rich in manganese is cast iron, and cast iron is much less oxidable than steel. The physical and chemical composition of the metal has therefore, a great influence.

"The catalytic action of manganese may be represented by the curve of Fig. 9, the metals under consideration being very closely allied in composition and physical properties, and differing only by their percentage of manganese.

Higher Steam Pressures

THE TENDENCY of American practice is toward the use of an operating boiler steam pressure of 300 lb. and 650 deg. F. Some plants favor 350 lb. and 700 deg.

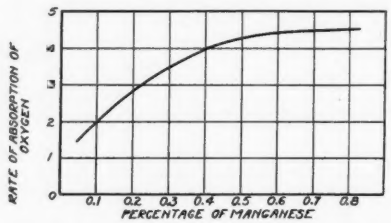


FIG. 9. VELOCITY OF ABSORPTION OF OXYGEN FOR DEGASSER

Foreign practice tends towards slightly higher pressures and to temperatures approaching 750 deg. F. In one European plant a pressure of 475 lb. is used.

In connection with valves and fittings, it should be noted that the oil refineries are successfully operating at 400 lb. pressure and 900 deg. temperature in their stills and pipe lines. The operating conditions are extremely severe, as an oil leak at these temperatures means a fire; the temperature of the oil being far above the fire point.

The General Electric Co. offers the binary vapor mercury turbine outfit as an alternative, which they regard as a more favorable development than going to very much higher steam temperatures and pressures.

On the other hand, a German advocating an improved type of reciprocating engine operating at 900 lb. pressure, claims very considerably increased efficiency based upon experimental results obtained with a small engine and boiler.

The member companies operating the higher pressure plants report in general that these plants are giving as high efficiency as had been expected, and that the

increased cost of going to higher pressures and temperatures has been warranted. They did not feel, however, that with the material now available pressures over 400 lb. or temperatures higher than 700 deg. should be considered.

Concerning the mercury vapor installation which the General Electric Co. is building for the Hartford Electric Light Co., the following statement by the General Electric Co. should be of interest:

"While our policy in connection with this matter has been to avoid predictions which might require time in realization, so much interest has been aroused by the beginning of this commercial application, it may be well to publish, through the Association, an outline of the objects which we are seeking to accomplish.

"The apparatus designed may be regarded as a substitute for a 600-hp. steam boiler. It occupies the same floor space and uses the same furnace. The gases from the furnace pass through a mercury boiler. The vapor from this boiler passes through a simple form of turbine which drives a generator. The wheel of this turbine operates inside of a chamber where the vapor discharging from the turbine blades is condensed by contact with tubes containing water, its heat of condensation being taken up in the formation of steam at 200 lb. gage pressure. This condenser is situated above the mercury boiler and the liquid condensate runs back into the mercury boiler by gravity, passing through a liquid heater on its way. The steam made passes through a superheater and then goes out to any uses to which it may be put. The gases from furnace first pass through the mercury boiler, thence through the mercury liquid heater, then through the steam superheater, and finally through a feed water heater to the stack.

"For reasons of convenience and facility in accurate measurement, the Hartford apparatus is being arranged for oil burning, although it is equally well adapted to any kind of fuel. We expect to burn about 2300 lb. of oil per hour, vaporizing mercury at 35 lb. gage pressure corresponding to a temperature of 812 deg. F. The generator driven by the mercury turbine should give about 1800 kw. and we should deliver about 28,000 lb. of steam per hour to the station at 200 lb. gage and about 100 degrees superheat. These figures assume that feed water comes from station at 200 deg. F., and are based upon conservative assumptions as to combustion conditions.

"To build such an apparatus with definite prospect of complete reliability, it has been necessary to develop experimentally a very large amount of new knowledge, both in the matter of types and proportions and of construction details. Results equivalent to those stated above have been accomplished at Schenectady with mercury vapor at a slightly lower pressure and with apparatus which, for certain reasons, was not adapted without important changes to continuous commercial operation. Much experience has been gained, great simplification and improvements have been made and it is thought that the prospect of success at Hartford is very good."

Resume of Fuel Oil Situation

Crude petroleum production in the United States increased six per cent in the year 1921 over the year 1920, slightly falling behind the 9.3 per cent "compound interest" rate obtained since 1861. This maximum production was accompanied by maximum imports 18 per cent greater than in 1920. For the past three years, imports have been respectively 14, 24 and 27 per cent of domestic production. Exports increased barely two per cent over 1920. Consumption decreased one per cent, and was 56,000,000 bbl. more than the country produced. Stocks of crude oil increased by 60,000,000 barrels, or 49 per cent over 1920.

Prices at the end of 1921 were about two-thirds of those a year previous, with intermediate values as low as 37 per cent of the year's opening. Completed wells were only 62 per cent of the number in 1920.

Regional availability of fuel oil during 1921 remained remarkably constant as indicated by refinery outputs; the east coast district dropping at the end of the year to about 80 per cent of its output during the opening months. Probable underground supplies for the United States and the World are shown in segregated figures from the Geological Survey to be some 2,000,000,000 barrels more than estimated in the 1921 report; these two billion barrels being estimated to be within the United States.

Utilization of Waste Heat

Waste Heat, Produced as a By-Product in the Gas Industry May Be Profitably Saved

As a direct means of increasing efficiency and conserving both fuel and labor, the utilization of waste heat offers a profitable return on the investment necessary and is of immense value to such industries as have heat available as a by-product.

For a number of years past, considerable attention has been given this matter in the iron and steel, and metallurgical industries, but there is still much to be done both in these and in other fields. In designing new or in remodeling old steel mills it is now quite generally recognized that the fullest possible use of waste heat is absolutely necessary, because of its decided effect on efficiency and cost of production. It is now impossible to disregard it or even to use it with but poor efficiency. As a result of the savings shown here the subject is being given careful consideration in other industries, notably the gas industry.

Gas plants have an abundance of waste heat available which is now being allowed to go to waste, with the result that production costs are unnecessarily high. Waste heat boilers are now being used in a number of water-gas plants and the arrangement has proved efficient as far as exchange of heat is concerned, and is of unquestionable value in the saving of both fuel and labor.

A water-gas installation having a capacity of 1,000,000 cu. ft. a day will require from 6 to 7 T. of coke breeze as fuel. By the use of a waste heat boiler, this fuel can be saved as well as the labor required to handle it, and in addition there will be available an appreciable surplus of steam that may be used for the production of power. In passing through the boiler, the temperature of the waste gases may be reduced from an average of about 1400 to about 450 to 500 deg. F.

The evaporation obtainable will amount to as much as 90 lb. of steam from and at 212 deg. F. per 1000 cu. ft. of gas produced.

In general, such plants may be arranged in two classes from the point of view of the utilization of waste heat: (1) those using a separate stack for each retort, and (2) those using a common chimney for all units. In the first case, each stack must be connected to a separate boiler unit; in the second, one large boiler may be used in connection with the main collecting flue. In either case, the boiler is arranged in parallel with the chimney so that if need be the existing flue may act as a shunt or bypass around the boiler. In the first case, a small vertical water-tube boiler may be placed directly alongside the stack. A short connecting flue, one at the top and one at the bottom of the boiler, allows the gases to pass through the boiler. Between these two flues, in the stack, is a damper by means of which the volume of gases passing through the boiler may be controlled. With this damper closed, all the gases traverse the boiler; with it open, they discharge directly through the stack, just as if no boiler were used.

Unless a forced or induced draft fan is employed, the question of returning the gases to the stack at a temperature sufficiently high to produce the desired draft, will usually limit both the capacity and efficiency of such an installation.

A single waste heat flue common to all retorts undoubtedly presents more favorable conditions for waste heat utilization, as it makes possible the use of one large boiler unit instead of several detached units. Some tests recently made on such an installation employing a B. & W. boiler showed that one pound of coke carbonized 4.91 lb. of coal in the retorts and in addition evaporated 2.01 lb of water in the boiler. The inlet and outlet gas temperatures of the gases passing through the boiler were 1050 and 480 deg. F. respectively. To obtain this evaporation by direct firing would require an excess of ¼ lb. of coke. This fuel is of course saved as is also the labor necessary for firing it.

Wherever waste heat is produced in such quantities as it is in gas plants or where it can be utilized economically, there is no reason why it should not be used. Besides the immediate effect of reducing the cost of production, this practice will help toward the conservation of our fuel resources, a question which is yearly becoming more important.—From information given by W. Francis Goodrich in the Gas Engineer of England.

Oil Engine Hints

HOT IGNITION; MISSING; HUNTING; FAILURE TO START; LOSS OF COMPRESSION; COMPRESSION CARD. BY BERT BARE

OIL engines vary in style from the low compression "hot head" or "hot plate" type to the high pressure "full Diesel" with air injected fuel. Where a cheap engine is desired it is necessary to keep the pressures down to convenient figures so that the parts, to take care of the stresses that will be encountered, do not become too massive. In this type of engine the pressure at the end of the compression stroke will naturally be comparatively low. Where this pressure does not reach a value of over 125 to 150 lb. per sq. in., it will be found that the temperature is not high enough to cause ignition. That is why this type of engine must use some extra source of heat. This is usually done with a "hot head," "hot plate" or "hot bulb."

The amount of unjacketed, or uncooled surface will depend in a general way on the amount of compression used; the particular design of heating surface will be a minor consideration. Where the design requires a comparatively large uncooled surface, it will be found that the engine runs best at its normal rated load or a little under. At higher loads, it has sometimes been necessary to introduce water into the suction air so as to keep the hot surface from becoming too hot. Where this has been found advantageous, it will also be found that the engine will not run at light loads and when running idle, will finally stop; this, because the burning oil has not been of sufficient quantity to keep up the required heat in the hot surface to cause ignition.

MISSING AT LIGHT LOAD

THIS is overcome in various ways. The first idea will be to supply artificial load, which is done, although it means an additional use of fuel. This additional amount of fuel will, however, be found to be small. In some engines a change in the timing will keep the engine hot. Advancing the injection will have the same effect as retarding the spark in a gas engine. The basic principle in either case is supplying more heat than that required for the light load running condition.

In the "hot bulb" type where it is not necessary to resort to water injection in order to keep the engine cool, it may be found difficult to keep the engine running at light load. There may be a number of reasons for this and the cure, of course, depends on the disease. One of the causes may be the "lean mixture effect. In a gas engine the mixture may be too rich and will not ignite; or it may also be too lean to ignite. In an oil engine where a very efficient spray nozzle is used, fine results will be obtained when the engine is running at full load, but at light loads there is a tendency to "miss" and finally stop. The cause will be found in the fact that the spray is too efficient and that the mixture gets too lean before it reaches the hot surface. If a less efficient nozzle be used and the oil directed toward the hot surface, it will be found that the engine does better at the lighter loads. The nature of the average load will therefore determine the best type of nozzle to use.

When the hot bulb does not stay hot for full running load, it means that the fault lies in the power of the engineer to correct. The nozzle tip may have become burned off or scale may have formed at the nozzle tip so as to destroy the normal spraying action. In this case, a clean tip should be supplied. When a new tip is put in place and the bulb fails to remain hot, it may be due to directing the fuel stream at wrong angles. A little experimenting will soon lead to the proper direction and the engine will behave normally again.

In some types of engine where the spray does not strike the hot surface directly, but hits a directing surface, there may be trouble with keeping the engine run

ning, due to the accumulation of carbon on the bulb. Carbon is a good insulator and therefore will not let the heat pass to the bulb so that it cools, with consequent bothersome results. The carbon should be removed and overloading the engine should in the future be avoided as much as possible.

Light Load Governing

Some low compression engines when running light have a tendency to "miss," not due to the spraying action. This "hit or miss" action may be due to two other causes, both of which are constructional features and can be remedied only by alteration of the parts at fault. The governor may be too sensitive and inclined to "hunt." In this case, a change correcting the governor spring to suit the particular engine can be figured out and applied. Generally too many turns in the spring coil are the cause of this "hunting" action. Where a light flywheel is fitted, it is useless to try to use a sensitive governor because the speed variation during one revolution of the engine will be greater than the range of the governor from light to full load running, and the regulation will then be highly erratic. The generally accepted range in speed of rotation for ordinary power purposes amounts to about ten per cent from light to full load, the higher speed obtaining at the light load running condition.

The second cause of "missing" may be the use of an injection plunger that is comparatively too large in diameter for satisfactory action at the light load resulting in very short stroke. The "give" in the parts between the governor and the pump will be sufficient to take up the motion required by the governor with no resulting injection of fuel. When the governor does finally cause fuel injection, the amount will be so large as to cause a heavy explosion, resulting in "hunting" not due directly to governor design. The cure in this case lies in fitting a smaller plunger and, if necessary, to obtain the additional stroke, a further change in the design of the controlling mechanism.

Keeping the Engine Hot

The trouble with a "missing" engine is that the heat is not striking the "hot bulb" often enough to keep it in the proper condition. The engine of moderate compression (250 to 350 lb. per sq. in.) is designed with the idea of getting an engine to operate, when fully running, as a "full Diesel"; in fact, it is a "full Diesel" with the compression as low as the designer can get the engine to turn over as such when everything is in perfect order and the engine is hot. With this type of engine it is, therefore, necessary to provide some means for extra heating at starting from "stone cold." An electric coil is quite a favorite means. A "punk" is also used to advantage. In this type the oil spray must be of the most efficient character. Here it is not necessary for the oil to reach a hot surface, but it is necessary that the oil be in its best possible form for ignition. The air right at the nozzle tip will be hot enough so that it is not necessary for the spray to have the carrying power that is so vital in the engines with lower compression. The nozzles are usually quite small and often more than one are used per cylinder.

It is important that the nozzle tips be kept in perfect condition. It is also best to keep the engine as warm as possible without undue heating of any part. Control of the cooling-water temperature will naturally, then, be an important item in the best operation of this type of engine and will be in whole under the jurisdiction of the engineer in charge.

If there is no sign of starting up from "cold" the trouble may be due to the electric ignition where such is used. This presupposes that the normal precautions in starting have been taken and there is still no sign of "life." After seeing that all the connections are tight and that there is plenty of "juice" at the source, the next thing to investigate should be the heating coil. Where the engine has been running for some time in good condition, there is a possibility that the coil may have burned out and replacement with a spare one that has been kept on hand will be all that is necessary. In some types of engine, the coil is so arranged that it can be withdrawn from the cylinder after the engine has been running for a while. In this case, there is less chance of the coil burning out.

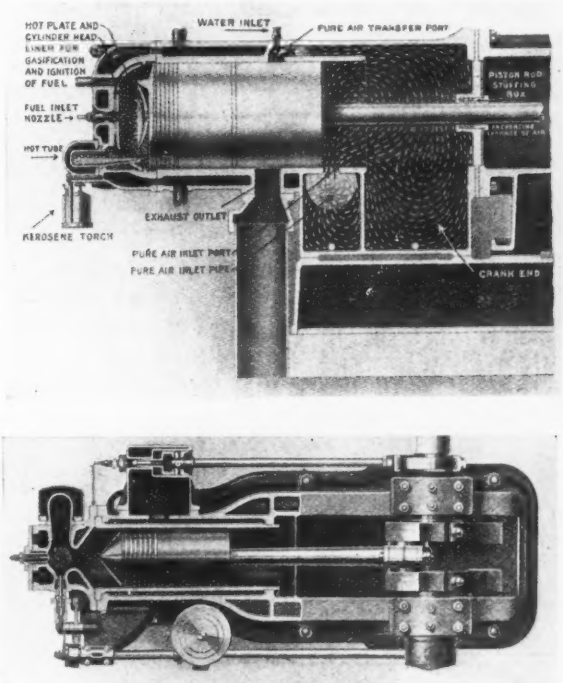


FIG. 1. A. HOT PLATE IGNITION TYPE OF 2-CYCLE OIL ENGINE. B. HOT BULB IGNITION TYPE

Carbon is less liable to accumulate in this type of engine than in the low compression type, but where the scavenging is not good carbon will be found present. In this case, the effect of carbon will be quite the opposite of that in the lower compression engine. On account of the greater heat, the insulating qualities of the carbon will prevent the proper cooling of any projecting parts, as valves and nozzles, or any features in the design of the heating chamber having such projecting part. The heat will tend to be unevenly distributed, causing heat stresses and if not corrected will result in cracked heads or pistons. Exhaust should be carefully watched to see that there is no undue smoke and this

will keep carbon troubles at a minimum. Regulation will not materially affect this type of engine.

The high compression or "full Diesel" engine of either mechanical or air injection, will normally have no trouble in starting or in keeping running. If there is trouble in either starting or running, the difficulty will be found in causes that have not previously been described but which are applicable to all the types of engines. These causes may be described as those which can be prevented by the ordinary care dictated by accepted practice. The troubles may be separated into two classes. One will cover the causes of insufficient heat and the other will cover the failure of the fuel.

Where the low compression type is considered, it is usually necessary to heat the hot surface until it has reached the temperature that experiment has shown to be required for the particular engine under consideration. The general heat required will be available when the "hot surface" has been heated to a dull red glow observable when the "bulb" is shaded from light. A more definite way of telling when the "bulb" temperature is high enough is to have priming cups fitted so

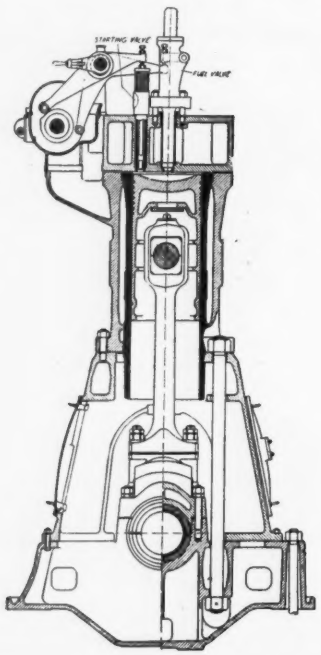


FIG. 2. SECTION OF DIESEL ENGINE. NOTE PROVISION FOR SHIMMING END OF CONNECTING ROD TO CONTROL COMPRESSION PRESSURE

that fuel can be allowed to flow into the combustion chamber. When, on allowing this fuel to flow into the combustion chamber a vapor emerges, the "bulb" is heated enough. It should be remembered that it is best not to force the heat of the surface too much as there is danger of overheating on the spot where the flame most forcefully strikes. This will weaken that point and burn it away so that when starting up the pressure of the explosion from the inside may blow a hole right through the heated surface. It depends on the engine, but usually about 15 or 20 min. is required to get the surface up to heat.

Where medium compression engines are considered, it will take only a few moments to perform the operations necessary for starting. Where a "punk" is used, the only "time out" will be that required to light and put this apparatus in place. Where an electric coil is used, a few seconds will be sufficient to allow the coil to be thoroughly heated.

Loss of Compression

In the "full Diesel" type no heating arrangement is necessary. There is another cause that will reduce the normal heat and this will be found in a loss of compression. That is due mainly to the piston rings and to some extent to leaky valves, where valves are used. Where the loss of compression is due to a leaky valve, replacement by a freshly ground valve together with its seat and cage kept for just such a case will correct the fault immediately. Where the piston rings are at fault, the compression can be taken care of to some extent without going to all the trouble of drawing the piston. Most engines of the low compression type and all of the high compression type are fitted for shimming somewhere between the piston and the crankpin bearing. By shimming up to the required pressure, the engine will give satisfaction, at times for a long period and in such a case this method of handling will have been justified. However, where the engine "passes" air by the piston for only a short time when starting up and the engine is cold and where there is satisfactory operation when fully running and warmed up, the trouble will be found in the "gumming" of the piston rings. This bypassing of the air can be detected by listening for a "hiss" in the crank space beneath the affected cylinder.

In the case of the two-cycle engine with the lower part of the main piston as a scavenging piston, the "hiss" is not readily obtainable and resort to a pressure gage attached to the indicator tap on the cylinder where a check valve has been placed in the line and the line choked down to prevent pounding the needle of the gage, will give the compression pressure when the fuel to the cylinder has been stopped. In this way also the maximum pressure in the cylinder can be obtained by letting the pressure build itself up. The pressure recorded by the gage will be the maximum. Where bypassing occurs, it will require a little longer in starting up, so that the successive compressions will have time to heat the cylinder a little and aid in raising the temperature of the air in the succeeding cycles.

In the "full Diesel" type, the "gumming" may be caused by using a heavy fuel oil which works its way down and lodges between the rings and the piston. It is not advisable to shim up in this case because the cylinder will work well when warmed up. A few pounds difference in the compression in any of the types of engine will not affect their working conditions to any great extent. In the low compression engines, it would require a lot of shimming to change the pressure materially so that the question of shimming applies to the "full Diesel" type particularly. Here a shim of about 1/32 in. will make a difference of about 15 to 20 lb. per sq. in., depending on the stroke.

By taking a compression card after the engine has been running for a while, the compression pressure can readily be obtained. For the proper distribution of load in a multi-cylinder engine all the compressions should

be the same. This is particularly necessary in the "full Diesel" type and a little care in the shimming will bring about this result. Most of the engines are now fitted up so that it is an easy matter to take indicator cards and compression cards should be taken occasionally. In taking a compression card, it is only necessary to "cut out" the fuel to the cylinder being indicated, for the few strokes that it requires actually to take the card. This card will, then, record the pressure of the air only. The highest point on the card indicates the compression pressure sought. It is not absolutely necessary to know just what this pressure is, as cards from all the cylinders should be made the same; but if the calibration of the spring in pounds per inch of travel is known, the pressure of compression is easily calculated. An indicator that has been specially designed to stand up to the high pressures and that is made light enough to avoid giving inertia effects to the cards at the relatively high speeds of oil engines, should, in all cases, be used.

Priming to Start Up

The second cause of failure to start may be due to careless priming. The low compression engines get their fuel quite a time before top dead center and hand levers are usually provided for hand pumping. Where the engine tries to take hold but does not seem quite able to the task, a few strokes of the hand pump quickly applied will usually get the engine rolling nicely. It may make a little racket, but the main thing is to get the engine turning over. If the engine runs as long as the hand pumping continues, but stops when the hand pumping stops, the cause may be found in an air pocket in the line. At the highest point in the fuel line, there will be a valve to let out any air that may have become trapped therein. The pump should be worked by hand until there is a good overflow from this valve and the valve closed while the fuel is flowing.

Sometimes the pump itself may become air bound. This will show itself very plainly when trying to start up after the noon shut-down. The engine will still be warm and so in good condition for immediate starting. If a few turns of the engine cause no signs of "life," the pump should be looked after and newly primed. If this brings results, the air leak through the packing or lapping should be corrected at the first opportunity. It will be well in all cases to prime the engine before attempting to start up, so as to conserve the air for starting. If from experience the lines have been found to remain tight over a period of time, the precaution of priming need not enter into the operation of the engine as much as in the case where the engine is not so well attended.

The Price Horizontal Engine

Combustion at Constant Volume, Solid Injection of Fuel in Two Sprays

OPERATING on the four-stroke cycle, with single horizontal cylinder, this engine presents some novel features of operation and design which make for simplification and convenience.

Fuel injection takes place just before the piston has reached the head end of the cylinder, as shown in Fig. 1, the two sprays impinging on each other in a combustion chamber of special shape so as to be agitated by the current of air thrown into the combustion chamber by the compression stroke. This results in complete atomization of the fuel and a thorough mixture with

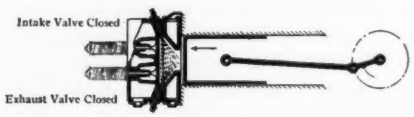


FIG. 1. POSITION OF PARTS AT INJECTION

air, giving rapid combustion, at constant volume, with pressure rising as shown in the diagram, Fig. 2. As the piston starts forward, there is a short period of combustion at constant pressure, followed by expansion. The rest of the cycle is the same as for any four-cycle engine.

Variation from the usual Diesel cycle is, as noted above, that part of the combustion is at constant volume, taking place while the piston is on dead center, the rest at constant pressure as the piston starts forward.

As the engine uses no high-pressure injection air, the only pump needed is for the fuel, starting air being taken from bottles which are filled by a separate compressor unit. The fuel pump, seen at the left in Fig. 3 is contained with the service pump,—which draws the oil from the supply tank and forces it to an elevated filter, whence it flows by gravity to the injection

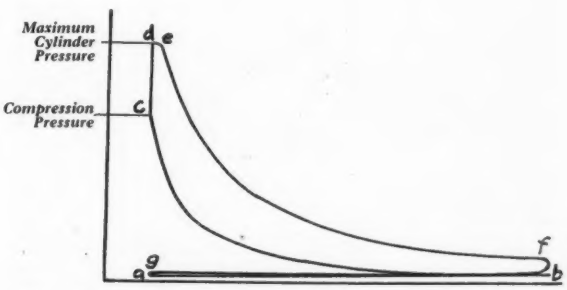


FIG. 2. INDICATOR DIAGRAM FROM PRICE OIL ENGINE

pump,—in a solid block of steel. The injection plunger works in the upper part of this block and the service pump in the lower part, both being connected to a yoke.

This yoke is operated by a rod with a roller on its end, actuated from the cam shaft for the discharge stroke and returned by a strong spring which keeps the roller at all times in contact with the cam. The plungers are of hardened steel, lapped into their barrels so that stuffing boxes and glands are not needed. Suction and discharge valves are spring loaded, hardened, ground and lapped to bearing on the seats; discharge and bypass connections are made with ground joints and held in place by a steel clamp, making a leak-proof system. The bypass valve is closed by a spring and opened by a lever connected to the pump plunger, the

point of opening or cutoff being regulated by the governor through shifting of the fulcrum on which this lever bears.

Pump action starts as soon as the engine is turned over by the starting air, the fuel oil being forced through a divided pipe so that half goes to each injection nozzle. The setting of the pump cam gives injection at the proper point in the stroke of the piston.

As indicated in Fig. 1 and shown in Fig. 4, the inner head is in two sections secured by stud bolts and fitted with ground joints without gaskets. The inner head section contains the starting air valve, and the outer section the intake and exhaust valves, spray nozzles and indicator connection; it also carries a bracket for the levers operating the exhaust and intake valves, connections for the exhaust and intake pipes and for the cooling water pipes. These latter are carried outside the cylinder jacket to avoid any chance of water being drawn into the cylinder through leaking joints.

Cast integral with the main frame, the cylinder is fitted with a semi-steel liner, pressed in. One end bears against a shoulder, while the other is free to expand, a tight joint for the water jacket being furnished by rubber rings fitted into grooves in the free end. The liner can be easily removed.

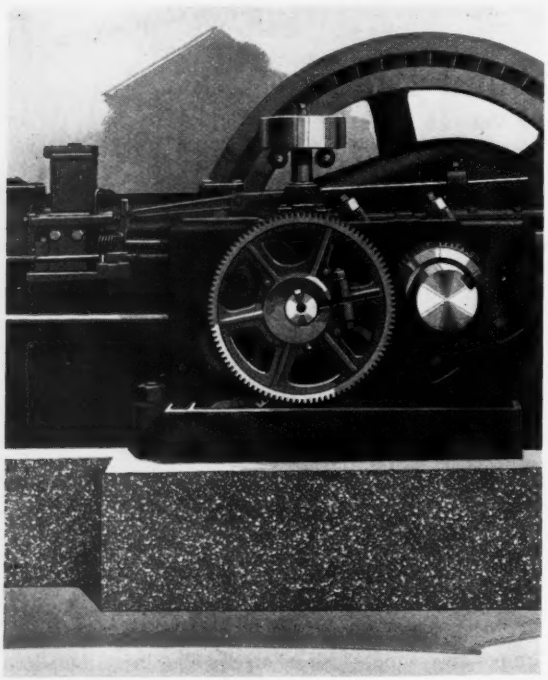


FIG. 3. MAIN BEARINGS, CAM GEAR, GOVERNOR AND FUEL PUMP

A trunk piston is used with one snap fire ring at the head end and special piston rings beyond. These rings have a single outer section with beveled face, six inner sections with face beveled to match that of the outer section and six steel springs which force the rings out against the cylinder walls and by the wedge action keep the rings in contact with the sides of the grooves, thus sealing the cylinder against the passage of lubricating oil inward and gases outward. An oil wiper ring is fitted near the crank end, the space between this and the working rings being vented to atmosphere so that oil and burned gases are carried away instead of going to the crank case.

Marine type connecting rod is used, drilled to carry oil from the crankpin to the piston pin and having shims at the crank end by which the length of the rod can be changed to regulate compression. The piston pin bearing is wedge adjusted and may be reached from the crank case without removing the piston from the cylinder. The single throw shaft is counterweighted and runs in two main bearings, which are split at an angle so that adjustment will be in the direction of wear. The crank and shaft are enclosed by a cast-iron cover having machined surfaces and a cord gasket to make it oil tight, the construction being seen in Figs. 3 and 4.

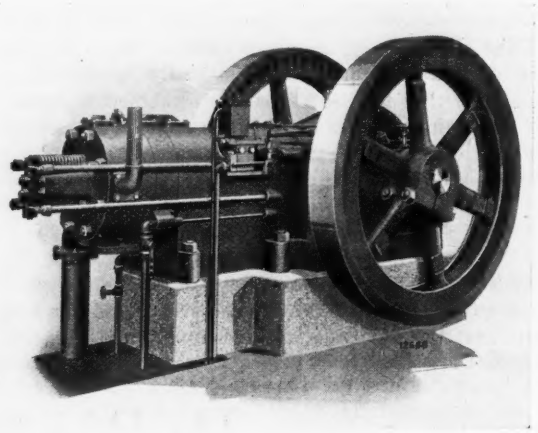


FIG. 4. SIDE VIEW OF PRICE 100-HP. OIL ENGINE

Pressure lubrication is used, the pump being located in a compartment at the side of the engine and driven from the cam shaft as seen in the lower part of Fig. 3. Part of the oil is passed through a filter, so that eventually the entire body of oil is filtered at regular intervals. The cylinder is oiled by the oil thrown from the crank, any excess being taken to a dirty oil compartment from which it is drawn off at intervals, to be reclaimed and returned to the system.

Valves are operated from the cam shaft by push rods and levers having a ball and socket joint between the lever and the end of the push rod, with contact maintained by the valve spring. The starting valve is operated during the starting period by a rod passing through an opening in the frame and receiving its motion from the cam shaft.

Dimensions of these engines, which are made by the Ingersoll-Rand Co., are for the 50-hp. 12¾ in. bore by 14 in. stroke, and for the 100-hp., 17 in. bore by 19 in. stroke. The makers state that these engines operate successfully on all commercial grades of crude oil and that the fuel guaranteed for both sizes is 0.45 lb. per brake hp. hr.

THE $65,000 STEAM plant of the Denver, Rio Grande and Western Railroad, located in South Denver, Colo., was badly damaged by fire on the night of June 10. It is thought that the fire started in a pile of shavings allowed to rest against a smokestack which later on "warmed up."

Oil Engine Comment

By M. S. Howard

IN THE article on "Oil Engine Hints," appearing in the June 1 issue, are a number of statements, which may cause the operator some confusion. As to sulphur in the fuel oil, if sulphur mixes with water, sulphurous, not sulphuric, acid will form, but not from a combination of sulphur and steam. In the Diesel cylinder, or for that matter in the semi-Diesel cylinder, the temperature is always above the condensation point; consequently no sulphurous acid will form. This applies equally to the exhaust lines during operation, as no water will appear. On the other hand, upon stopping, the temperature of the exhaust line falls rather sharply and water of condensation will appear, hence, if the fuel carries much sulphur, some acid will now form; and if the fuel oil carries more than 0.5 per cent of sulphur, it is better to start and stop on kerosene, using this oil for 10 to 20 min.

Fuel consumption of semi-Diesels at full load is given as 0.5 lb. per b.hp. It is agreed that on a shop test several semi-Diesels may do it; but in actual service, after a month's run or so, I claim that there is no record of a semi-Diesel doing this well.

Oil Pumps

The type of fuel pump described is not used on latest Diesels, and the method given of caring for the pump valves applies only to engines which were built before 1912. No modern Diesel has the suction valve stems extending outside the pump with packed stems, but the old American engine had the Begtrup governor using this type of suction valve. Besides, modern Diesels use either poppet or mushroom pump discharge valves as well as suction valves, which must be ground to the seat. The ball type discharge valve described has been little used since 1912.

Even with the valve described, it is unnecessary to purchase a new cage when the valve lift becomes greater than 1/16 in. The lift makes little difference; the object is to have the ball seat quickly. So all that is needed is to add a small coil spring over the ball—saving $14, the price of a new cage.

Oil and Cooling

As to oil cooling of the piston head of large engines, only a few engines, mostly those for marine use, have oil for cooling. In the marine Diesel some makers have felt that sea water might cause salt deposits in the head, and so used oil. Many marine builders use a supply of fresh water, and in some cases raw sea water. In stationary service, water is universally used. The reason for not using oil is that its specific heat is much less than that of water, consequently its velocity of flow must be greater; moreover, heat will not pass to the oil as easily as to water and a greater difference in temperature must exist between the piston metal and the oil.

Discussion on the splash system is fairly accurate, but the operator of the engine using that system should not throw away the crank case oil if it looks black. Blackness of the oil indicates the absorption of a lot of very fine carbon particles. The way to test the oil is to see whether it feels greasy when rubbed between the fingers. If it feels "gritty," it should be removed,—not thrown away, but recovered by separation.

I know of no N. S. engine that ever had a four-stage air compressor. All use two and three-stage, and only the small ones use a two-stage.

The best treatment for bad cooling water is to use a set of cooling coils inside which the engine cooling water (raw or distilled), flows, while raw water flows down outside the coils. In this manner no scale can get into the jackets. The system is as cheap to install as an ammonia condenser. For a 100-hp. engine, five coils of 2-in. pipe 20 ft. long are enough.

Bearing pressure on the average will be much lower than the 50 lb, per sq. in. given as the limit. While thick clay and gravel will carry as a maximum up to that limit, the base for a 500-hp. engine with generator will be 10 by 26 ft., or 260 sq. ft. = 37,440 sq. in. The weight will be about 300 lb. per hp., or 150,000 lb., giving 4 lb. per sq. in. on the foundation bearing. Hence, the usual bearing pressures are less than 1/10 the maximum limit given.

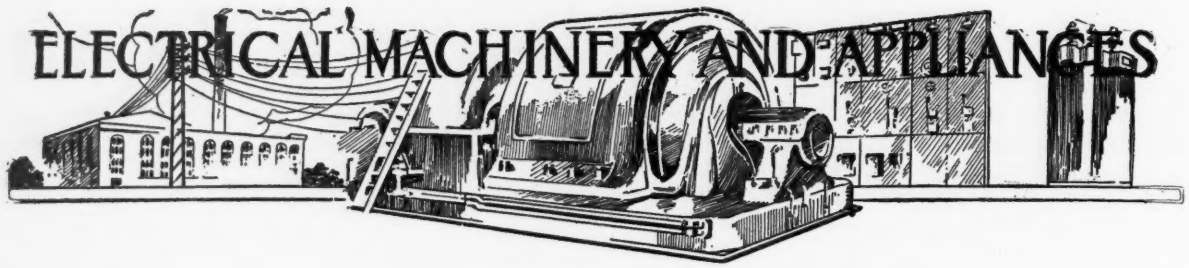
On semi-Diesels the statement was made that, if the compression pressure drops to 100 lb. the engine will fire irregularly. So far so good; but this does not prove that the air cannot be throttled. Many semi-Diesels do throttle the air though it is done by a hand-operated damper. On low loads this throttling lowers the amount of air blowing into the cylinders and part of the exhaust gases are left in the cylinder, thus helping to raise the temperature of the piston head and hot bulb and insuring ignition on low loads when the hot bulb gets too cold to fire the oil.

Running the jacket outlet at 180 to 200 deg. F. is bad, as this is too high for safety. If the discharge is this hot there will be certain points inside the jacket where the water is hotter; steam will be generated and, if the jacket system is one in which there are dead high points, these places will fill with steam and the casting will be overheated. A temperature of 140 deg. is plenty, though on low loads 160 deg. is permissible.

The discussion on solid injection engines is not complete. The elastic fuel pipe described was used on the English Vickers engine but was abandoned in favor of a spring loaded accumulator. There are a number of solid injection engines built in this country, one using a spring-loaded relief valve to keep up the pressure, the others using a direct pump injection and no expansion pipe of any kind.

Orders for fabricated structural steel placed during April were almost equal to the capacity of fabricating firms, according to reports made to the Department of Commerce by firms comprising two-thirds of the fabricating capacity of the United States. Sales reported during April amounted to 115,247 T. by 75 firms having a capacity of 116,916 T., or at the rate of 99 per cent of capacity. At this rate, the total sales throughout the United States, based on a total capacity of 180,000 T., were 177,600 T. in April. This compares with 139,300 T. reported for March by the Bridge Builders and Structural Society, based on reports of 64 firms showing sales at 77 per cent of capacity.

The fellow who takes his enjoyment as he goes along is sure of it.



Auto Transformers---I

WHAT THEY ARE, THEIR THEORY OF OPERATION, AND THEIR ADVANTAGES OVER TWO-WINDING TYPE OF TRANSFORMERS. BY FRANK C. VOGAN

AUTO TRANSFORMERS, which are also termed balance coils and compensators are really single circuit transformers; that is, instead of having two electrical circuits, a primary and secondary, as in the case in the ordinary transformer, they have only one circuit which serves as both primary and secondary.

FIG. 1. A TYPICAL 3-WIRE, 220/110 V. BALANCE COIL

They have a number of important applications in electrical engineering, particularly in alternating current distribution work for obtaining 110 v. lighting current from circuits operating at voltages of 220 and 440. When used in this class of service, they are usually called balance coils. Commercially, balance coils are divided into two main classifications, those built to furnish three wire 220-110-v. service from 220-v. sources and those for use on circuits operating on 440 v. from which is derived a five wire 110 v. system for lighting. These systems are diagrammatically illustrated in Fig. 2.

The outward appearance of the balance coil is very similar to that of the ordinary two-winding transformer as will be observed from Fig. 1, which shows a Westinghouse coil built for three-wire 220-110-v. service.

The balance coil has an iron core like the usual transformer, but, as stated above, has only one electrical circuit, which, as will be seen in Fig. 2, is tapped at various points. In the ordinary two-winding transformer, the power transformed is the same as the power output, this, however, is not so for the auto-transformer. In the balance coil, the power transformed is always less than the output; that this statement is true will be shown in the explanation of Fig. 3. Another point to be mentioned is that for a given voltage, the size of the transformer varies in direct proportion to the power transformed. With this fact fixed in mind, it will be seen that a saving will result if it is possible to obtain a given output without transforming all of the power. The auto-transformer does just this.

Further explanation of the auto-transformer is not possible without the use of some arithmetic and diagrams, but it is promised that the operating man shall not be intrigued into deep waters if he follows on, as the quantities used are quite simple and their workings are not complex.

ESSENTIALS AND THEORY

THE MATTER in this section applies to the diagram in Fig. 3, and should be carefully noted, as it covers the fundamentals of the action of auto-transformers in general.

If an alternating potential is impressed across terminals "C-D," a magnetizing current will flow in the winding marked common and series. This will give rise

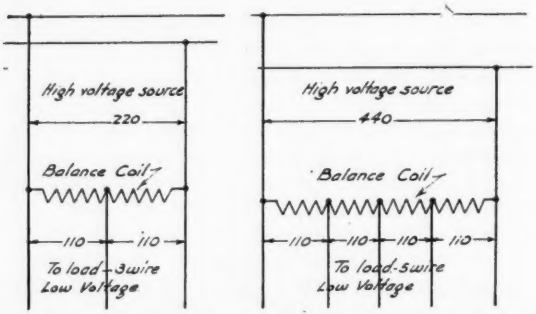


FIG. 2. BALANCE COILS ON 3-WIRE, 220/110 V. AND ON 5-WIRE 440/110 V. SYSTEMS

to an alternating flux which will link every turn of the common and series winding between point C-D, and will induce therein an alternating potential. The potential between any two taps, as D-F, is then proportional to the number of turns existing between the taps; in other words, any ratio of potential is possible. If the secondary D-F is loaded, a current will flow in the primary, but the primary and secondary currents will flow in the two parts of the winding marked common and series as shown in the figure.

In the diagram, a non-inductive load is represented as L. In either the straight transformer or in the auto-transformer, the component parts of this load are E_2

and I_2, the load being the product of the factors mentioned, or $E_2 \times I_2$.

In Fig. 3 A, it will be assumed that E_1 is greater than E_2, or that the voltage in the primary of the straight transformer is higher than the voltage in the secondary; also, that the current is proportionately lower in the primary than in the secondary. In consideration of this statement, the input is the same as the output, or all of the power is transformed.

In Fig. 3 B, an auto-transformer to take care of the same output is shown in diagram. In this sketch it will be seen that the section of the coil marked series, is comparable with the primary winding of the straight transformer shown in Fig. 3 A. It will further be observed that the value of the potential across the series winding in Fig. 3 B is less than the potential across the primary winding in Fig. 3 A, or the value E, for the straight transformer is reduced to $E_1 - E_2$ for the auto-transformer. The reduction in potential has also been accompanied by a reduction in the current value for the common winding in the auto-transformer, or, if in Fig. 3A the value of the current in the secondary is I_2, in Fig. 3 B it becomes $I_2 - I_1$.

From the foregoing, it is plain that the number of turns in the auto-transformer series winding are less than those in the primary of the straight transformer, and further, that the cross section of the copper in the common winding of the auto-transformer is less than in the secondary of the straight transformer.

Further study of the diagram shows that for the auto-transformer, the power transformed is equivalent to the product of the potential by the current in the

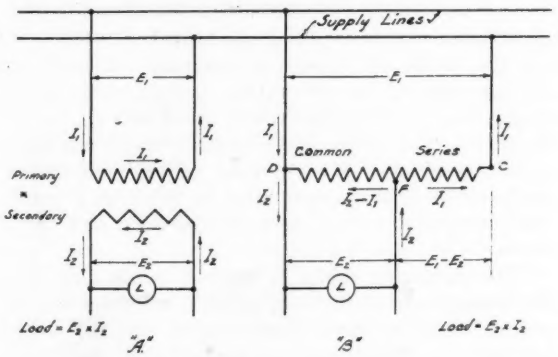


FIG. 3. DIAGRAM ILLUSTRATING ACTION OF BALANCE COIL

respective windings or $(E_1 - E_2) \times I_1 = E_2 \times (I_2 - I_1)$. For the power transformer, we can say that it equals $\frac{E_1 - E_2}{E_1} \times$ power output.

The remainder of the power may be thought of as passing through the apparatus without any transformer action.

Again referring to the diagram, if point F is moved toward point C, the potential $E_1 - E_2$ will become smaller and the power transformed becomes less. This all leads to cheapening the cost of the unit. On the other hand, should point F be moved closer to point D, the potential $E_1 - E_2$ becomes larger, the power transformed greater, and less economy results.

Auto-transformers are designed on the basis of regular two winding units and are worked out as if they possessed both primary and secondary windings. All of the electrical characteristics, reactance, resistance, exciting current, losses, etc., are handled in balance coil design in about the same manner as for straight transformers. So much for the design.

The properties that interest the plant man, or the purchaser, are the operating characteristics—these are best thought of and treated on the basis of the auto-transformer and prove that in the balance coil—percentages of regulation, losses, exciting current, etc., are less than for the two winding transformer of the same output by a ratio shown in $E_1 - E_2$, and that the efficiency is correspondingly increased.

Examples, Showing Current and Voltage Relations

In order that the reader may become familiar with the working relations that exist between the terms ordinarily applied to auto-transformers, some examples

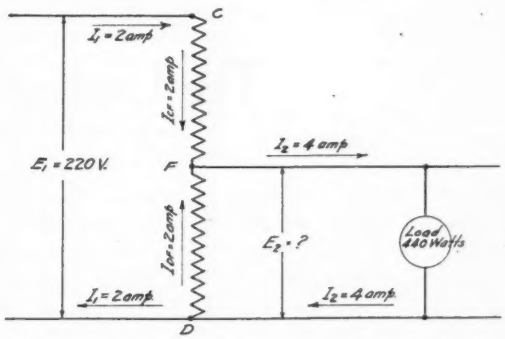


FIG. 4. DIAGRAM USED IN ILLUSTRATING METHODS OF SOLVING BALANCE COIL PROBLEMS

involving the terms in question are worked out in actual figures. Attention is directed to Fig. 4, to which the following terms apply:

Let N_1 = the total number of turns between C and D = 22 turns.

N_2 = the total number of turns between D and F = 11 turns.

E_1 = voltage across terminal D to C = 220 v.

E_2 = ?

By formula $E_2 = \frac{N_2}{N_1} \times E_1$.

$E_2 = \frac{11}{22} \times 220 = 110$ v.

Let I_1 = the current entering terminal C = 2 amp.

I_2 = ?

By formula $I_2 = \frac{N_1}{N_2} \times I_1$.

$I_2 = \frac{22}{11} \times 2 = 4$ amp.

Required — to find value of IDF.

By formula $I_{DF} = I_2 - I_1$

$I_{DF} = 4 - 2 = 2$ amp.

or by another method of development

$$\text{IDF} = \frac{N_1 - N_2}{N_2} \times I_1$$

$$\text{IDF} = \frac{11}{22 - 11} \times 2 = 2 \text{ amp.}$$

From the foregoing, the values of IFC can easily be determined.

AUTO-TRANSFORMERS VERSUS TWO WINDING TRANSFORMERS

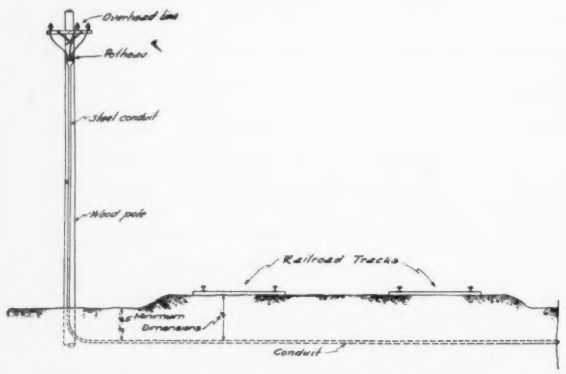
FOR N_2 (the number of turns between D and F) to equal one-half of N_1 (the number of turns between D and C), the current in D to F would exactly equal the current in F to C although the direction of flow would be in the opposite way at the instant. With this in mind, it is plain that for a two to one transformation only one winding of a two winding transformer would be necessary, provided a tap was available at the middle of the winding. Under these conditions, there would be no flow of current in the second winding and therefore no heating of the second circuit. The heating of the transformer would then be less than if it were used as a two winding unit, moreover, a greater output could thus be obtained without exceeding the nominal temperature rise. In general, for the same power input with a given connected load, an auto-transformer requires but $\frac{E_1 - E_2}{E_1}$ of the copper necessary for a two-circuit transformer. In the ratio mentioned E_1 = the high voltage or primary potential, and E_2 = the low voltage or secondary potential.

For instance, to illustrate the economy of an auto-transformer over a two-circuit unit for a given load, attention is asked to the following example: Where $E_1 = 220$ v. and $E_2 = 110$ v., the copper ratio referred to above would be $\frac{E_1 - E_2}{E_1} = \frac{220 - 110}{220} = \frac{1}{2}$. The higher the ratio of transformation, the less becomes the saving in copper—thus if $E_1 = 440$ v. and $E_2 = 110$ v. the copper ratio would be $\frac{440 - 110}{440} = \frac{3}{4}$.

The Underground Cable System

POINTS TO BE KEPT IN MIND IN THE DESIGN AND CONSTRUCTION OF UNDERGROUND SYSTEMS. BY WILLIAM S. JONES

THE CABLE system of past years has been the weakest part of the electric plant and this is, perhaps, still true today with the most modern methods of construction. It may safely be said that there has not been the rapid improvement, in connection with this part of the plant, which has obtained with the generating and control equipment and the utilizing devices. More care should be given to the selection of materials, alinement and protection of ducts and to the pulling and splicing of cables, always bearing in mind cost of service, rather than cost of initial installation.



UNDERGROUND CONDUIT CROSSING RAILROAD TRACK

The reliability of service and the cost of service are invariably on opposite ends of the "seesaw",—the one being inversely proportional to the other to a greater or less degree. Transmission systems are changed from overhead to underground with expectation of increased reliability and decreased maintenance cost. If we are to leave the installation and maintenance of the underground system to unskilled or poorly trained hands, as is done much too often, the real purpose of underground construction is defeated.

FIRST UNDERGROUND SYSTEMS

THE FIRST cables placed underground were buried directly in the earth with a covering of sand and, although the cables were rather crudely made up, this arrangement gave comparatively good service. As this was 40 yr. or more ago, when electric service was neither especially reliable nor expected to be, comparatively good service of those days must be taken at a discount when compared with present day methods and requirements.

The placing of cables in wooden troughs and filling the troughs with hot pitch, or similar bituminous compounds, was the first improvement on the original method. A trench was excavated and the wooden trough, made up of taroil soaked plank, was set in place to receive the cables. After cables were laid and the trough filled with compound, a wooden cover was placed on top and the trench refilled with earth. This method is in use today in other countries and, with the more perfect cables now obtainable, gives fairly reliable service. It has, however, one serious objection, in that it becomes necessary to dig up the whole trench in order to replace, or add to, the cable installation.

Several other systems, such as the "Edison tube," consisting of asphaltum-compound-insulated copper rods in iron pipe, and the "Crompton" trench system, in which bare, copper strips were secured in notched insulators supported on oak timbers which were embedded in a cement-lined trench provided with a flagstone cover, were used to some extent in various localities but did not come into general use.

Duct System

The modern system, which is used most extensively in this country, is commonly known as the "drawing-in," or "duct," system. This system, when properly installed with provision for future extension, permits the drawing-in of new cables for replacement without disturbing the ground surface and causing obstruction to traffic in the roadways or streets under which such cable may be run.

The Cable System

The first step in the layout of a conduit system is to design the cable system, which it is intended to serve, constantly bearing in mind real economy, efficiency, reliability and future growth, studying the troubles which are liable or possible to occur and providing, as far as possible, facilities to meet them. Feeders should be, as far as practicable, of as few different sizes as the system will permit. This will reduce to a minimum the amount of emergency cable, switches and other apparatus necessary for stock.

In the accompanying table are given the sizes and cables which are recommended for use in underground work. In determining the sizes of the cables indicated in the table, the current-carrying capacity, rather than the circular mil area, was the governing factor. It is believed that multiple conductor cable should be limited in size to 300,000 c.m. and that, where capacities are required greater than a cable of this size will permit, several such cables should be paralleled rather than to use a larger size, which would be very cumbersome to handle and more liable to damage while being installed. It will be noted from the table that, while the 500-000-c.m. rubber insulated cable is 66⅔ per cent greater in circular mil area, it has but about 45 per cent additional current-carrying capacity over the 300,000-c.m. cable, due to its lack of proportionate radiating surface.

Diversity Factor of Loads

In deciding on required cable sizes, the designer or engineer should always bear in mind that the maximum demand of a group of loads is generally less than the sum of the several maxima. This diversity factor varies with the job, depending upon the character of the load and the purpose for which it will be used,—being higher for lighting loads in business or industrial sections and lower for lighting loads in residential sections and power in industrial sections. It has been found, by actual investigation and measurement, that the maximum power demand for machine tools in a very large shop does not exceed 33⅓ per cent of the rated total connected load, and the average load, not in excess of 25 per cent. This percentage will increase as the number of motor-driven machines decreases and their individual power requirements increase.

Selection of Cable-Position in Duct Line

Before pulling in cables, it would be well to make a study of the ducts to be used, keeping in mind that the most desirable selection in one manhole may be the most objectionable one in the next. Care should be taken not to obstruct vacant ducts and, for this reason, the center ducts should generally be left until last. Heavily loaded cables should be placed in lower, corner ducts, whenever possible, so that they will not be influenced by heat from other cables. Considerable difficulty has been experienced in installing two-conductor cable made up in flat shape, due to the cable twisting or kinking. Cables for underground work should always be made up round. This is a very important consideration.

In providing cable racks in manholes, provision should be made, and the right position left, for future cables. If avoidable, cables should never be run from one side of manhole to the other and should always be so disposed as not to interfere with the withdrawing and replacing of any other cable. This is a point which is sometimes not recognized until the necessity for withdrawing occurs. When pulling cable from a manhole to a pole or wall of building, the pulling should be done at the manhole, feeding the cable from the other end. In the case of conduit running up a pole, as is shown in accompanying illustration, it is found necessary, at times, to feed the cable from the bed at base of pole and then to slip the vertical run of conduit over the cable.

Connection of Cables

All cables of an underground system should be lead-sheathed and, where terminating, should be provided with potheads. The lead sleeve wiped joint, while having proven satisfactory in service, is gradually giving way to subway junction and splice boxes, which are provided with means of readily disconnecting a branch tap or breaking a main run. Instead of having a solidly spliced-in system, which requires the cutting of cable to disconnect a faulty section, the trend is now towards some provision of readily sectionalizing the sub-feeders. Subway devices are now being manufactured and they have proven in service to given as satisfactory results as the wiped-sleeve joint, with the important additional feature above mentioned.

RECOMMENDED SIZES OF ELECTRIC CABLES

Cir Mils	B & S Gauge	No. of Conductors	Approximate current carrying Capacity	
			Rubber	Paper and Varn. cloth
26,000	6	1, 2, & 3	50	70
42,000	4	"	70	90
84,000	1	"	100	150
133,000	00	"	150	225
211,000	0000	"	225	300
300,000		"	275	400
500,000		1	400	600
750,000		"	525	800
1,000,000		"	650	975
1,500,000		"	850	1,300
2,000,000		"	1,050	1,600

Provision should be made to enable the identification of all cables at the manholes. Each cable should have, permanently attached to it, a suitable designation tag. The tags should be of brass and made in several shapes so that cables of different voltages may be readily distinguished, one from the other. In cases where cables of high and low potential are carried through the same manhole, a coat of red paint, on the high potential cables, has been found to be a wise safeguard from the viewpoint of life hazard.

The lead sheaths of all cables, in the manhole, should be bonded together and grounded. The bonding can be most efficiently accomplished by the use of No. 6, or No. 4, solid, bare, copper wire, soldered to the sheath

with a soldering iron. A very satisfactory earth connection may be obtained from a 1-in. galvanized iron pipe, driven in to the bed of the manhole excavation before the construction of the manhole is started. This pipe should be so driven that it will extend, at a convenient location, up, near the manhole wall, to a height of 2 or 3 ft. above the floor.

It is not within the scope of this article to go into the detail of cable testing. Cables should be tested at the factory or warehouse, just before shipment. A reasonable and what may be considered as a thorough test of the completed installation is to apply, for 30 min., a voltage double that at which the system is intended to operate.

Jet Condenser Performance

THE RESULTS OF AN ACCEPTANCE TEST ON A LOW-LEVEL MULTI-JET CONDENSER INSTALLATION FOR CENTRAL STATION SERVICE. BY A. L. PENNIMAN

IN JANUARY, 1921, the Consolidated Gas, Electric Light & Power Co., of Baltimore, installed two Schutte & Koerting low-level, multi-jet condensers to serve a 9000-kw. General Electric turbine.

An interesting feature of this twin jet condenser installation is its simplicity. There are no removal or air pumps; the air, non-condensible gases and water being removed from the condenser by the cooling water, on the ejector principle. The only pumps required are

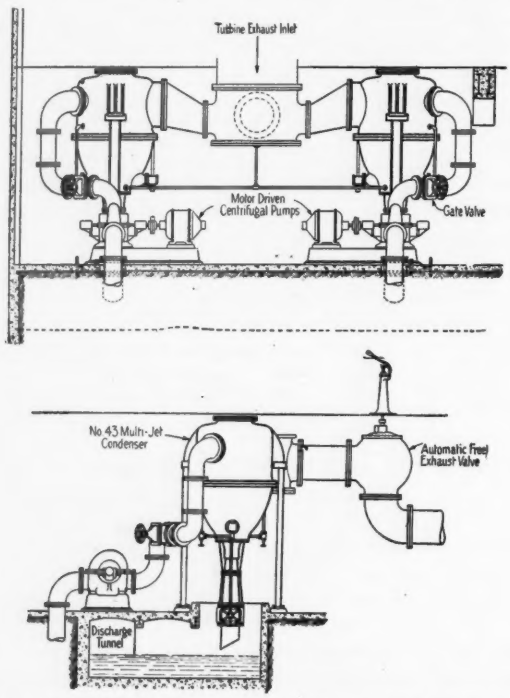


FIG. 1. DIAGRAMMATIC ARRANGEMENT OF THE TWIN LOW-LEVEL MULTI-JET CONDENSER INSTALLATION AT THE BALTIMORE CONSOLIDATED GAS, ELECTRIC LIGHT & POWER CO.

A sectional elevation of this condenser is shown in Fig. 2. It consists of a condenser body of closed cylindrical chamber, the upper end of which contains a water

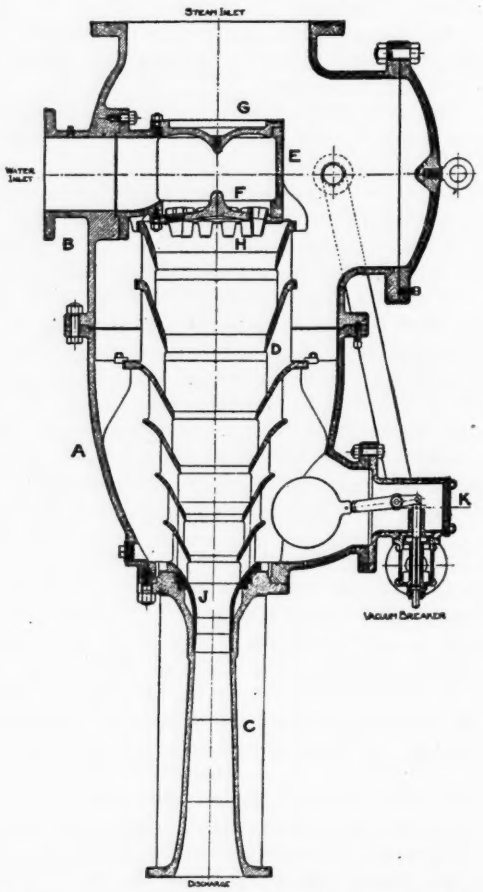


FIG. 2. SECTIONAL ELEVATION OF THE LOW-LEVEL MULTI-JET CONDENSER

two Cameron pumps, motor driven, centrifugal, for supplying the injection water to the condensers. A plan and elevation of the installation are shown in Fig. 1.

The manufacturer's guarantee was 28.25 in. vacuum referred to a 30-in. barometer at full load with 70 deg. F. injection water. In the acceptance test the guarantee specified was exceeded by 0.08 in. Because of the value of the test results obtained and their significance as to what may be expected of jet condensers of this type under the conditions existing in central station service, test results are given in detail.

nozzle case, below which is fitted a combining tube consisting of several sets of tapering rings joined together by equally spaced ribs. The combining tube is connected to a tail diffuser discharging into a hot well underneath.

The water nozzle case is provided with a nozzle plate containing the water nozzles. The injection water is supplied to the condensers under a pressure of about 10 lb. per sq. in., corresponding to a 23-ft. head, and is discharged through the water nozzles, which are designed to pass a specified amount of water, depending

upon the conditions of flow determined by the water pressure and the existing vacuum. As the water jets emerge from the nozzles, they are directed into the throat of the combining tube, where they unite to form a single jet.

Exhaust steam enters the condenser chamber through the exhaust steam inlet, flows through the annular passages between the tapering rings, comes into contact with the converging water jets and is condensed. Because of the combined effect of the external water pressure, the vacuum existing in the condenser, and gravity, the multiple water jets attain a velocity which is sufficient to entrain the condensed steam, air and non-condensible gases, and to discharge them into the hot well against the pressure of the atmosphere. The water jets create the vacuum by condensing the steam, and maintain it by entraining and removing the air and non-condensible gases.

The energy of the water jets is sufficient to overcome the friction and back pressure in the tail diffuser, wherein the velocity head of the water is converted into a pressure head that is large enough to overcome atmospheric pressure.

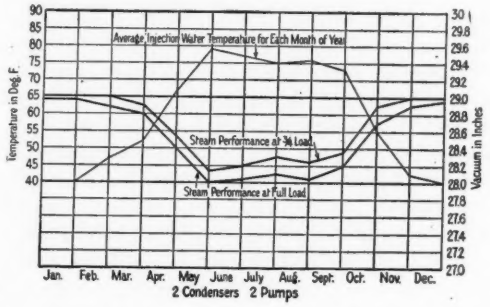

Average Injection Water Temperature for Each Month of Year
Steam Performance at ¾ Load
Steam Performance at Full Load
Temperature in Deg. F.
Vacuum in Inches
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.
2 Condensers 2 Pumps

FIG. 3. ALL YEAR PERFORMANCE OF TWO MULTI-JET CONDENSERS UNDER ¾ AND FULL LOAD CONDITIONS

This condenser requires a greater water to steam ratio than other low level types, because the water accomplishes the removal of both water and air from the condenser. The total power required to operate the multi-jet compares favorably, however, with that required by other jet condensers. This is so because the pump supplying the injection water operates under conditions favorable to centrifugal pumps, that is, under a low suction head, and thus the maximum pump efficiency is obtained.

Figure 3 gives the all-year performance of the two multi-jet condensers under ¾ and full load conditions, corresponding to 84,000 and 112,000 lb. of steam per hr. respectively. As shown by the chart, at no time did the vacuum fall below 28 in., even in summer, when the temperature of the injection water was as high at 78 deg. F.

The accompanying table itemizes the performance test data. During the test the water temperature was nearly 1 deg. F. higher than that called for in the guarantee.

CONDENSER TEST DATA

Average load of unit, kw	7450.00
Steam pressure at throttle, lb. gage	177.90
Steam temperature at throttle, deg. F	477.50
Barometer reading, inches of mercury	30.04
Vacuum on condenser, referred to 30 in. barometer	28.33
Absolute pressure in condenser, inches of mercury	1.67

	Condenser A	Condenser B
Injection water pressure at inlet, lb. per sq. in.	10.40	10.20
Injection water (calculated from pressure in nozzles) gal. per min.	10,312.00	10,273.00
Injection water temperature, deg. F.	70.70	71.00
Temperature of water discharged, deg. F.	81.40	80.60
Temperature rise of injection water, deg. F.	10.70	9.60

Total steam by flow meter, lb. per hr.	111,246.00
Total injection water, gal. per min.	20,585.00
Water to steam ratio, overall	92.50
Water rate of turbine (using flow meter reading) lb. per kw.-hr.	14.95

Overall water to steam ratio and water rate are figured from flow meter readings. The amount of injection water used was calculated from the pressure on the condenser nozzles.

The vacuum of 28.33 in. (based on a 30 in. barometer) obtained was 0.08 in. in excess of the guarantee of 28.25 in.

It is possible with the twin condenser arrangement to shut down one unit and to operate with one condenser and one injection pump only, during periods of light load or during the cold season. Thus a spare unit is available at all times in case one of the condensers or pumps has to be shut down for overhauling, or in an emergency.

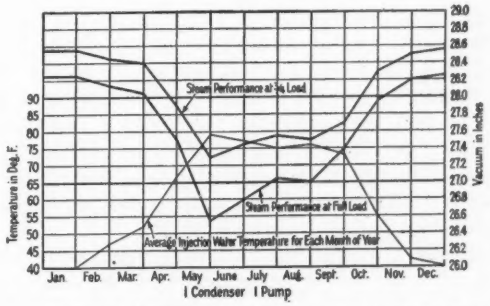

Steam Performance at ¾ Load
Steam Performance at Full Load
Average Injection Water Temperature for Each Month of Year
Temperature in Deg. F.
Vacuum in Inches
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.
1 Condenser 1 Pump

FIG. 4. VACUUM PERFORMANCE OF ONE MULTI-JET CONDENSER UNDER FULL AND ¾ LOAD

The fact that the water is supplied by pumps external to the condensers and that the continuity of water supply is entirely independent of the vacuum in the condensers, increases the reliability of the unit and lowers the maintenance costs and the time out of service for repairs.

In the twin arrangement, the tail pipes of both condensers are equipped with gate valves in the discharge. When the gate valve of the idle condenser is closed, the possibility of flooding this condenser is eliminated, and any water that may seep through from the hot well, due to the suction effect of the vacuum, is drained off into the operating condenser by means of an equalizing pipe

connecting the two condenser chambers, directly above the tail throat. This equalizing line also takes care of any condensation that may collect in the idle condenser.

The performance of one condenser with full and ¾ load, and with various water temperatures, is shown in Fig. 4.

One Night

By Robert P. Harris

MIDNIGHT, black velvet and close-shut with fog. Street lamps making weak, futile effort to break down the wall of mist which shut in each house; the houses giving up the struggle to send out rays of cheer to the wayfarer, and settling to rest. The station load falling to the street circuits and those places where men turn night into day for the service of their fellows or for their own pleasure. No sign of unusual happenings as the fireman, the assistant and I settled down for the light load run.

A slight drizzle, companionable against the windows, and causing thankfulness that the outside lines would probably need no attention, for the shower seemed likely to pass over soon.

The small center-crank was pulling the lights and power on a belted a.c. generator, whirring away contentedly. And then—Bang! A terrific thunder clap! The belt gave a wild shriek and jump on its pulleys, and the whole plant and city went dark.

Ed, the fireman, yelled out, "What the hell!" Jake, the assistant, cried, "Great tomcats!". And I was so startled that I couldn't speak or think for a moment.

No light. The black velvet was now everywhere, in the plant as well as outside. And after the one flash and clap the storm had fled with low rumbling chuckles over the damage it had done.

One thing was certain. The engine was running and the belt flapping, and they had to be stopped. I yelled to Ed to slow down his fires, as the safety valves were beginning to pop, and felt my way to the switchboard to pull the switches. This done, I told Jake to shut down the little engine, and started for the cross-compound to try to get some light in the plant. Of course I was in a hurry and didn't take much time to warm her up before I gave her steam.

She was a condensing unit with four piston valves, the cutoff valve stems being held into the cams by set screws, and just as she got up to speed, with the throttle wide open, there was a back kick that jarred the foundations. I jammed the throttle shut and called to Jake to bring a lantern.

She slowed down all right and we tried it again, Jake walking all around with the lantern to hunt for trouble. There was no sign of anything wrong, but as she neared speed, again that back kick and jolt. And this time I shut the throttle even quicker.

Jake, who was peering around in the valve gear, suddenly said, "Here she is. There's a big gouge on this valve stem." And examination showed that one of the cutoff valve stems had pulled part way out of the cam, the set screw making a deep scratch.

We took off the bonnet and set the valve back at what seemed the right position. Fortunately there were tram marks on the stem and cam, and I had memorized the distance when setting the valve before; so we checked this, set up the screw and put her back in shape.

This time I warmed her up carefully and started slowly, with the satisfaction of having her pick up speed smoothly, then take over the load, and soon the plant was alight and the outside circuits showing normal current, though we closed circuits somewhat gingerly, not knowing what the lightning might have done on the lines.

That much done, I took stock of the unit that had quit. The engine and belt were all right, but the armature smelled hot, and the field winding was smoking in the series coils. Some way to cool them down was the next problem.

I called in Jake, and we stretched a run of fire hose from the generator to the boiler room, while Ed coupled up the flue blower hose to its nozzle. We stuck the blower hose a ways into the fire hose and tamped in waste around it to make a joint, then blew out steam through the fire hose line until it came dry and clear.

I started the generator turning slowly while Jake blew out the armature and coils with the dry steam, which soon stopped the smouldering and cooled down the windings so that further damage would not occur.

That done, we called it a night, and the plant ran quietly to the end of the shift.

It appeared later that a lightning arrester had failed to work and the stroke had gone through the armature and series field, but apparently did no other damage than the ruin of the insulation, so that new windings had to be put on.

The engine trouble with the cross-compound was due to hurry. The valve had heated up quickly, but the seat was not given time, so gripped the valve, causing the steam to slip under the set screw. This left the port wide open, so that the piston on its return stroke was met by full boiler pressure, slowing the engine down. This threw the governor down, pulling the other steam valve wide open and resulting in a heavy shot on that end which caused the jar in the effort to speed up quickly. If the throttle had not been closed quickly, it is doubtful what might have happened. But I was satisfied with the ones that had followed, and did not care for further experiments. The chief agreed with me as to the cause of the difficulty, and also, *heartily*, with the idea that it is wise to "make haste slowly" at all times, even in emergencies.

As soon as possible, the valve, seat, valve gear and rods were taken out and examined, but were found to be uninjured and not sprung, so that, fortunately, the results of my haste were not serious for the engine, but the one night taught me a lesson which has stuck ever since.

Advices from the oil fields of Texas are that many of the drillers who are able to secure electricity to drive their machinery are grabbing at it, for Safety First, and because, as they say, it is better for their purpose. The power is more uniformly distributed than when steam or gasoline engines are used, and it is more easily handled. Another, and no doubt the prime reason, why electrical machinery is preferred is the fact that many of the fires occurring in the oil fields were due to the flame necessary in steam firing and the careless handling of gasoline when that power was used.

Ice and Cold Storage From an Oil Engine

THE PLANT OF THE HOME ICE AND COLD STORAGE CO., AUSTIN, TEX., AS SEEN BY JOHN PIERCE

NOT BEING a professional writer, I shall have to put my article before the public according to my own way of looking at the matter, and in my own manner of speech. With this apology to you, patient readers, I am going to tell you of a plant consisting of a few pumps, motors, ice machines and a Busch-Sulzer Diesel engine.

It was very cold this morning when I started for this plant; a nasty, drizzly rain was falling, and I feared that it might prejudice me as it had against Texas, and everything in Texas, but when I got to the place and found it as it was, and found a fine fellow there in charge, with two mighty fine assistants, and saw how cheerful they were, and what they had to put up with, I found that life was not so bad for me after all; for of all the cramped and dismal places that a white human is asked to work in, I surely found it right there.

The chief engineer is Mr. Riffe, and considering the way his plant is arranged, this man is surely one of the most patient of men, for he faces the daily grind with a smile, and really keeps good-humored enough to keep that Diesel running like a new-born Ingersoll watch.

The engine is No. 308, is 12 yr. old, and has run almost constantly all this time, the motor-driven auxiliary being called on but little during all these years.

The engine is the old type "A" with triplex cylinders 16 by 24 in. and runs 170 r.p.m. She is running merrily along, as if life held nothing unpleasant for her. The oil used is 32 gravity black oil, not exactly a crude oil, but what is known in this part of the world as "gas" oil.

I will admit that this is a new name to me, for I have always heard oils called fuel, crude, solar, or kerosene, and never before today learned that down here they have a grade called "gas" oil, yet since the various engineers all called it the same thing, I suppose it is merely another case of my not knowing everything.

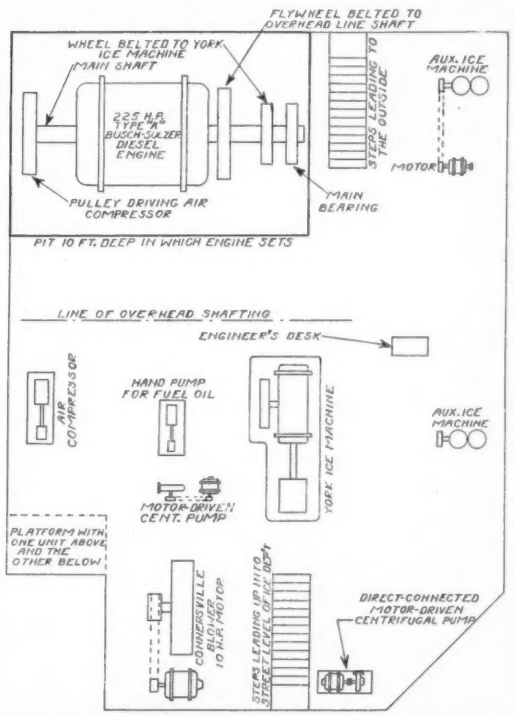
There is no data of the operation of the engine, and the engineer told me that he was under the impression that she was running economically, but when asked as to why he thought so, replied that he "did not know" but just "judged that she was." Well, he is the man who runs her, and I suppose that if anybody knows whether she uses her fuel in a saving manner, he should be the one, so I find no fault in his judgment.

I should like to give a lot of data on the performance of the machine; but I can't do so, for I was not long with her, and there being none on record, each of you will have to form his own ideas as to whether or not the old girl is living up to her reputation. Personally I think she is.

The main ice machine in this plant is a York of 35 T. capacity, and she is doing all of that, so that the boys have no complaint to make of her. The auxiliary is a 25-T. machine of the same make, and is in fine shape, as it is used so little that it never gets out of condition.

Running loaded, the Diesel uses about 260 gal. of fuel per day of 24 hr., drives her own compressor, a belted line shaft overhead, and the 50-kw. Westinghouse generator, as well as the main ice machine. The generator is 3-phase and is used for local purposes only, such as driving the motors of the plant, and for the lighting of the office and buildings. The auxiliary is driven by a belted 100-kw., 3-phase motor, and takes its power from the city service. This auxiliary is to be taken out in the near future and another Busch-Sulzer Diesel is to take its place, giving a duplicate unit for the plant, and allowing the engines to be run alternately, or both at once as the case demands.

The Diesel is operated on 70 atmospheres of injection air, and does not smoke at that pressure, though with a lower gravity oil shows some signs of it. Over the engine there is no head room at all, and it is necessary


FLYWHEEL BELTED TO OVERHEAD LINE SHAFT
WHEEL BELTED TO YORK ICE MACHINE
MAIN SHAFT
225 H.P. TYPE "A" BUSCH-SULZER DIESEL ENGINE
STEPS LEADING TO THE OUTSIDE
AUX. ICE MACHINE
MOTOR
PULLEY DRIVING AIR COMPRESSOR
MAIN BEARING
PIT 10 FT. DEEP IN WHICH ENGINE SETS
LINE OF OVERHEAD SHAFTING
ENGINEER'S DESK
AIR COMPRESSOR
HAND PUMP FOR FUEL OIL
YORK ICE MACHINE
AUX. ICE MACHINE
MOTOR-DRIVEN CENT. PUMP
PLATFORM WITH ONE UNIT ABOVE AND THE OTHER BELOW
CONNERSVILLE BLOWER 10 H.P. MOTOR
STEPS LEADING UP TO STREET LEVEL OFFICE, ETC.
DIRECT-CONNECTED MOTOR-DRIVEN CENTRIFUGAL PUMP

SKETCH OF ARRANGEMENT OF MACHINERY IN THE PLANT

to take down the rod before it is possible to get the piston out. There is, however, a 2-T. Yale chain block running on a curved "I" beam that carries the load to the outside door once they manage to get it far enough out so that it may be hung on the blocks. The engine has broken two cylinders during the past 2 yr., and in the 12 yr. of service has cracked a great many cylinder heads.

The plant contains the Diesel engine, which is set in a pit some 10 ft. deep, and barely large enough to house the engine and shaft with its attendant bearing, and is almost inaccessible; for the engine room in its entirety is 10 ft. below the street level, and is reached by going through a hole some 4 ft. square in the outside wall and down a flight of steps, or by going 9 mi. around

through the rest of the building and coming down another stairway from that side. How one gets down into the pit where the engine is located is beyond me, for I saw no way of getting down unless it was to slide down the belt, or step about 6 ft. over onto the deck of the engine.

The flywheel end of the shaft carries a pulley that drives an overhead shaft which in turn drives the generator. On this same end of the crank-shaft is a second pulley that drives the main ice machine, as well as the main bearing at the end, and, of course, the flywheel. At the other end of the engine is found the pulley that is connected, by belt, to the Ingersoll-Rand three-stage air compressor. This pulley is only 4 in. from the wall, and from this you will readily see that the compressor is an equal distance. The plant is about 50 ft. wide by some 55 ft. long, or would be if it was rectangular, but from the sketch you can see that it has been cut off some on the corners of one end.

In this small room is, as I have said, the engine with its pulleys and belts, the York ice machine, which takes up considerable room itself, the auxiliary ice machine, and its attendant motor and belt, the air compressor, the hand pump for the engine's fuel oil, a work bench, the chief's desk, the generator, a 10-hp. motor driving a direct-connected Connersville blower (for this plant makes raw water ice, and has drop pipes to agitate the water as it freezes), switchboard, air bottles, a vise and hand drill, a 10-hp. motor direct-connected to a single-stage centrifugal pump, working against 40 lb. head pressure, 1000-gal. capacity, for the cooling tower of the ice plant as well as jacket water for engine, a duplicate of the above except that it has a 15-hp. motor driving it, a 7½-hp. motor belted to the agitator in the brine tank, the main valves of the brine tank coils, a 15-hp. motor direct-connected to a triplex single-acting pump, used for cold storage circulation, a 7½-hp. motor direct-connected to a single stage centrifugal pump, used for the same purpose as the triplex, one motor of unknown capacity used for driving a 2-T. freight elevator, and another set of extra pumps not connected up.

All this, in addition to the tools, wrenches, etc., that are always found around a plant, are contained in the one little room, and I repeat that the chief engineer must be a saint to stand up under it, for it is the darkest place on earth, and a man has almost to feel his way about, unless he wishes to put up with the constant glare of electric lights.

I can but remark that it is a shame that a man is called on to give good service,—and this chief is doing that,—and ask him to do it under conditions that are so against a man even trying to do good work.

Going outside the plant, I found a cooling tower 12 ft. in diameter and 40 ft. high, handling the cooling end of the plant, and using a 12-ft. fan running at 250 r.p.m.

This plant carries a "chief engineer" and two assistants. Two of the men are on duty together a part of the time. They work one man 4 hr. at the engine room as operator, and 6 hr. as a repair man, while the chief does 10 hr. straight duty and then comes on whenever the occasion demands it and does another little bit, while the other man does a straight 10 hr.

Summing it all up, I found a plant with good machinery, well kept and running well, good men at the throttle and with no fault to find in any way with the whole thing except that the management is sadly at fault in not helping themselves by building a decent place for their engines and equipment, also a little criticism of the chief for keeping books in his head instead of on paper.

Big Piston Repaired by Welding

THE accompanying illustration shows a 2800-lb. cast-iron piston of a Diesel engine after completion of a repair by oxy-acetylene welding. The piston was cracked across the head in the form of an X and is one of a series of 30 pistons which were damaged in a similar manner. In preparing this piston for welding, a standard cutting blowpipe was used to cut out a deep chamfer at the best angle for making the weld. Approximately 75 gal. of coal oil were used in preheating the

DIESEL ENGINE PISTON AFTER REPAIR BY WELDING

casting, 105 lb. of cast-iron rods were used as filler, six cylinders of oxygen and three tanks acetylene were consumed, and the work required 35 blowpipe hours.

The repair of the piston shown was so satisfactory that it was decided to weld the entire series of 30 pistons.

Test on Alcohol for Power

REPORT published in Engineering of London of results of tests of alcohol as fuel for combustion engines by the Empire Motor Fuels Committee of the Imperial Motor Transport Council indicates that alcohol can be used with compression pressures as low as those used on kerosene engines up to higher than are practicable with gasoline or benzol. Efficiency with alcohol is higher than for petroleum or benzol fuels. Spark must be further advanced for alcohol than for gasoline or benzol, especially for weak mixtures. No piston speed attained was too high to use the maximum effect from combustion of the alcohol mixture. There was no evidence of corrosion of the engine. Power output and efficiency were increased by low temperature of the circulating water. Supplying heat to the carburetor reduced the power output, but slightly increased the thermal efficiency.

The experiment covered fuel from 90 up to 99 per cent pure alcohol over all practicable ranges of mixture strength, piston speed, compression and temperature.

Why Pick on Ammonia?

By W. F. Schaphorst

An editorial in one of the numbers of Power Plant Engineering some months ago entitled "Why Pick on Acetylene" reminded the writer of another substance singled out from among other substances as being a very, very naughty substance, namely, ammonia—NH_3.

Ammonia finds its chief use in refrigerating apparatus and because of the fact that it has accidentally or otherwise caused the death of a number of people we now have all sorts of rulings against ammonia. The writer knows of an instance where a "consulting engineer" was employed to decide whether or not a certain kind of refrigerating apparatus should be used in a certain place. This "consulting engineer" asked only one question, namely, "Does the machinery use ammonia?"

The answer was, "Yes, the machine uses ammonia."

The "consultant's" reply was, "By all means, do not install the machine."

Some people have a horror of ice made by machinery because they can imagine that they taste ammonia. In one notable instance, a housewife complained to her ice man because the ice he delivered tasted of ammonia. She had read, you see, about this dreadful thing—ammonia. The ice man's only comment was: "That's funny. I can't understand it at all. This ice was cut out of the river last winter."

Again, a male clerk in a department store informed the writer that he could frequently taste the ammonia in their drinking water which was cooled by a small ice machine. Upon investigation, it was found that their machine uses carbon dioxide.

More recently, we have been hearing about the combustibility of ammonia. Ammonia is said to be dangerous because it will burn. As a matter of fact, pure ammonia will extinguish a fire. Of course, when ammonia gas is mixed with other combustibles combustion may result. When mixed with pure oxygen, combustion will result. But, even iron, in the presence of pure oxygen, will burn. Why condemn ammonia and make a lot of laws against ammonia, when something else in the presence of ammonia is to blame?

Ammonia is blamed for the number of explosions occurring from time to time in the refrigerating field. Admittedly, there are some explosions. It is probably true that the number of explosions per year is constantly increasing. But the real reason for the increase in number of explosions, accidents, etc., is that the population of the United States is constantly increasing, and with that increase in population there is an increase in use of steam power plant equipment, electrical equipment, and mechanical equipment in general, and also at the present time a very rapid increase in the use of refrigerating apparatus.

Boiler explosions are becoming more and more frequent in total but less and less frequent per 1,000,000 inhabitants. We know more about boilers now than ever, they are better made, they are made larger than ever, they are inspected regularly by insurance companies, water is treated so that the scale does not form inside the boiler, the water level in the boiler is maintained automatically, etc. The automatic method of boiler feed regulation has proved to be far more efficient and much safer than the old method of hand feed regulation. This is an important point in favor of automatic operation, and in favor of automatic safety devices. Also, under the larger steam boilers we nowadays find automatic stokers making it possible very often for a single man to supervise and actually operate a large power plant. These great improvements must be credited to invention, research and development—not to the fact that laws have been made to prevent accidents.

Remember, though, that in spite of all of this improvement, and in spite of all boiler laws, steam boilers, which have been in use for more than a hundred years, are not yet "absolutely" safe. There are records of explosions even where the best engineers were in charge. An engineer does not make a pipe any stronger, he does not improve the composition of steel or wrought iron, he cannot alter any physical or other defects in the structure of the apparatus over which he has charge. Laws against ammonia will not improve its physical characteristics, make it safer, or more dangerous. "Ammonia is ammonia," and will never be anything else but ammonia.

While on this subject—"Safety"—nothing of a mechanical nature is safe. We read of railroad wrecks daily, yet we all ride on trains. It is unsafe to eat because we may be poisoned. It is unsafe to walk on the streets because we may be run over or something may drop on us from a high building. Steam engines are not safe. Gas engines are not safe. Automobiles are not safe. Buildings are not safe. And in the same way ammonia is not safe. All of these things are unsafe to the public to some extent, yet they are tolerated because we consider them to be necessities.

A good example of an unsafe mechanical device, dangerous to the public, and yet permitted with very little restricting law is the automobile. An automobile is a power plant on wheels, the horsepower varying from as low as 20 to 100 and higher. These dangerous power plants are driven all over the city streets by anybody who can show that he or she is competent to procure a driver's license. It is not necessary for the driver to prove, for instance, that he has been an oiler for one year, that he understands electricity, that he knows the strength of wrought iron or that he knows anything about the theory or practice of automobile construction. All he has to know is how to start it, stop it, back it up, and operate it at several speeds. The examination is purely a demonstration and is not written.

Automobiles have killed people in numerous ways, by running over them, by backing into them, by running onto a sidewalk crowded with people—by turning upside down, by rolling over down an embankment, by jumping off a road into water and drowning the occupants, by catching fire because of the highly explosive and dangerous gasoline carried and burning some of the occupants, by asphyxiating with the gas in garages and in other ways too numerous to mention. The em-

ployment of an expert chauffeur does not seem to better matters. Chauffers simply drive all the faster and make living more dangerous for pedestrians.

I am not advocating laws to compel every operator of an automobile to be a college graduate. Very few agitators, if any, are advocating such laws. Refrigerating machines, and ammonia, not nearly so dangerous as automobiles, should be treated just as leniently or the growth of the refrigerating business will be stifled.

There is such a thing as carrying safety too far. Some lives would doubtless be saved by restricting train speeds to 5 mi. an hour, by having an advanced guard on horseback run along ahead of every train to be sure that there would be no possibility of collision, by restricting all buildings to one story in height, by compelling all automobile owners to employ a licensed engineer for a chauffeur, etc.

It must be remembered that loss of life in the initial stages of development of many mechanical devices is a common occurrence. For example, many men were killed during the development of the present oil and gas engine. In working on the Diesel oil engine, the late Dr. Diesel himself declared that he was nearly killed. In developing the aeroplane, the Wright brothers had many narrow escapes, but fortunately were not killed. Since that time, however, thousands of men have been killed in the evolution of the aeroplane which is not yet fully perfected, and which will doubtless kill many more before it can be considered safe, and even then, the writer predicts that it will not be absolutely safe.

In view of the ever increasing use of ammonia, our increasing knowledge of ammonia, and the relatively few accidents, our law makers must not be permitted to go into a frenzy every time they read of an accident. More laws are liable to restrict progress. Don't pick on ammonia.

Reducing Fuel Consumption in Fire Brick Plant

Installation of Stokers and Changes in Piping Cut Fuel Bill 40 Per Cent.

By R. S. Frederick

SOME YEARS ago, the company by which I am employed acquired a brickyard for the manufacture of fire brick. The power plant consisted of two 60-in. by 16-ft. horizontal return tubular boilers, hand-fired, one 100-hp. Chandler & Taylor slide valve engine and bought electric power for one 100-hp. 3-wire, 3-phase, 2300-v. motor, one 25-hp. motor and one 35-hp. motor. The boilers were equipped with hand-fired stationary shaking grates, 25 in. below boiler shell. Mounted on the main nozzle of each boiler was a dome, made like a receiver separator, 36 in. by 36 in., as shown in Fig. 1. Safety valves of the ball and lever type were set for 95 lb. gage. All fittings on main head and steam lines over 1¼ in. were malleable gas fittings. Pipe was all old and lots of it would not stand threading without buckling.

There were four brick drying kilns with a total of 33,600 lineal feet of 1-in. pipe in them. Only two of these could be carried by the boilers at one time, the full consumption being so high steps were taken to reduce it and abate the smoke nuisance, as they were two blocks from a hospital and numerous complaints had been entered.

Among the changes were a complete overhauling of all piping over boilers, clear to engine, new spring pop safety valves, repairing feed pump so that it could be used to return the hot condensate from heating system to boilers instead of running it over the bank to waste and feeding city water with an injector, and the installation of underfeed stokers under the boilers. I had located some second-hand Jones & Standard stokers at a large plant where they were changing to self-cleaning stokers, for $250 apiece, including the Cole automatic valves, a Sturtevant 36-in. fan, at $35, in running condition, and an upright engine to drive it. This engine was on the job.

The plant was running light at the time, so fan and engine were installed first. In small installations of this kind, the Cole automatics are usually driven from a pulley on the fan shaft; but there was no pulley on the shaft and partly on account of the room available, a pulley being on the opposite end of the engine shaft from the flywheel, from which the fan was driven, the Cole automatics were set in line with the engine shaft and driven from there. In this way we got the three pieces, engine, fan and Cole valves, in a space 5 by 8 ft. The layout is shown in Fig. 2.

A stoker was then installed under boiler No. 2, and as soon as it was ready, No. 1 was equipped. We dug out enough to drop the stokers down so that the dead plates were 48 in. below the boiler shell. Then we started on the pipe fitting. A new header was built of 6-in. extra heavy pipe and fittings as shown in Fig. 1. An Austin receiver separator was put in on the engine line and a grease extractor on the exhaust line, both equipped with traps. The boiler feed pump was overhauled and connected up to feed the water above the boiler tubes, instead of through the blowoff pipe, which required the attendant to travel clear around to the rear of the boilers to regulate the feed to either one. As revised each boiler had its check and feed valve on the boiler front. The old blowoff piping was taken out and new pipe and valves installed, so that either boiler could be blown down. As shown in Fig. 2 of the old layout, boiler No. 2 could be blown down individually but No. 1 could not without blowing down No. 2.

Marion rear-end soot blowers had been installed at some time in the past and set 8 in. above the center of the boiler, but no pipe was in evidence to get any steam to them. These were lined up and piped up and the tubes surely needed some cleaning. Figure 4 shows how the water column was piped up. The column also was set so that it showed 1½ in. of water in the glass when water was level with top of tubes. The lower connection was a nipple with elbow, pieces of 1-in. pipe 36 in. long, elbow and short nipple going into boiler shell on side and buried in brickwork of setting. This was changed to connect into the flue sheet in the smoke box with crosses and a pipe to blow the column down. Pipe was increased to 1¼ in. in place of 1 in. The water of condensation from the dry kilns was returned to a storage tank, in the boiler house by a system known as

a vacuum siphon. It raised the water 13 ft. as shown in Fig. 3. When the engine was running the exhaust steam was turned into the dry kilns.

There was a grease extractor on the exhaust line with a drain pipe leading out into the ground. The drain line was stopped up and somebody had removed the baffle of the separator and thrown it away. When we drained the receiving tank, we got four candy pailfuls of grease out of it right away and later we got a lot more. There was nothing automatic about this tank. There was a 2-in. pipe with a globe valve, for a drain, and a 1-in. water line with globe valve to make up and act as condensing water for the vacuum siphon. A 1-in. equalizer pipe was run back from top of receiving tank to steam supply line to dry kilns to keep the pressure in receiver down so that the siphon would work. Water was used out of this tank for a pug mill besides boiler feeding. It kept a man busy sometimes to keep the tank from going dry, running over, or else giving the siphon so much water that it would not lift the water from kilns up into the tank. The main supply was through a ½-in. meter and there was a line run about half a block down to a market gardener's place and when he started using water everything went wrong. It was changed to a 1-in. supply.

There was rather a peculiar arrangement of breeching, as shown in Fig. 2. There was a stack 36 in. by 12 ft. mounted on breeching. It had a swinging lid which was opened up when firing up the boilers. When steam was raised high enough to run the engine that drove the 100-in. fan, it was started up and cover put back on stack. This fan also served as a ventilator for the dry kilns; 0.1 in. of draft was the maximum attainable with a pressure of 2 oz. in the wind box, but this was constant, regardless of weather conditions, when the fan was running.

We took flue gas samples with a Hayes hand analyzer for three days, at 15 min. intervals, and found that we averaged pretty close to 12 per cent CO_2 where it was almost impossible to get over 8 per cent CO_2, hand firing.

Before starting the stokers we cleaned the boilers, having ¾-in. garden hose to wash out with and some scrapers I made. Three wheelbarrows of scale were removed from each boiler and if we had had a steam driven flue hammer, I believe we should have doubled the amount.

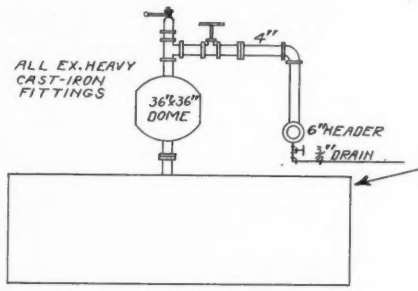


FIG. 1

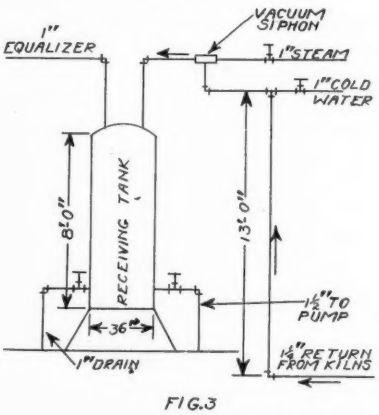


FIG. 3

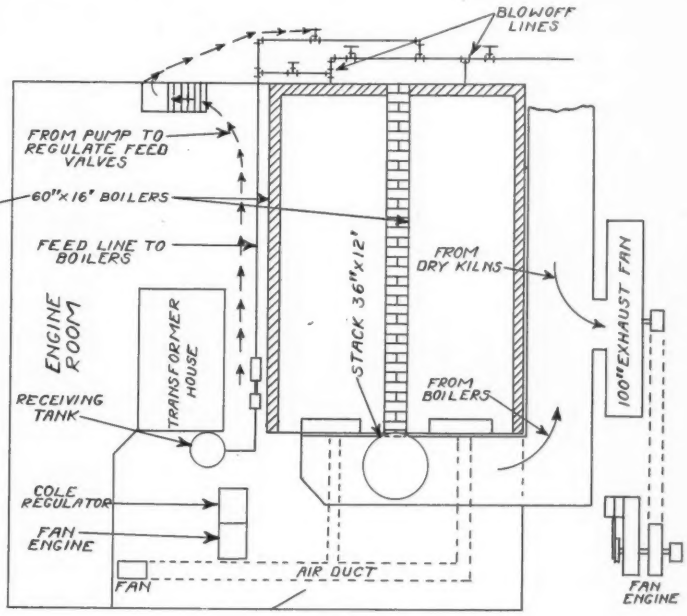


FIG. 2

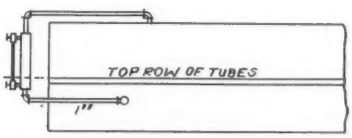


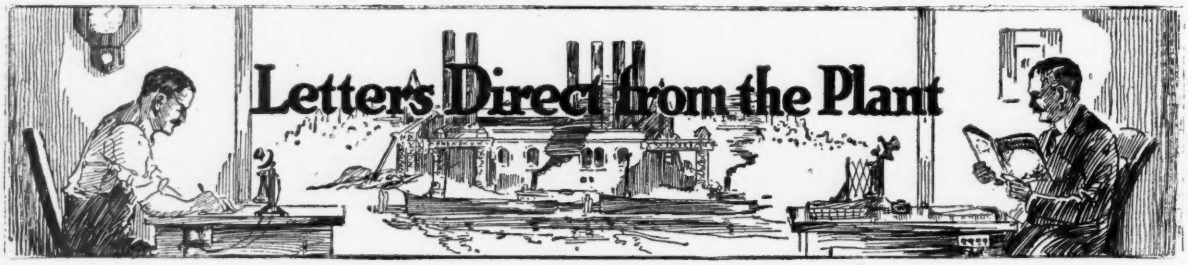
FIG. 4

FIG. 1. DOME AND HEADER LAYOUT AFTER OVERHAULING
FIG. 3. VACUUM SIPHON SYSTEM OF PIPING

FIG. 2. BOILER ROOM LAYOUT
FIG. 4. ORIGINAL WATER COLUMN CONNECTIONS

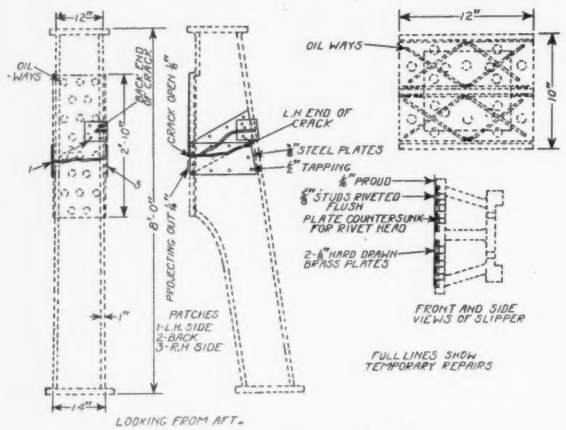
At last we were ready to start and after running for three weeks, the manager reported a 40 per cent reduction in the amount of fuel used.

AS AN INDICATION of what government control and management of coal mines might mean, the net cost to the British government for 4 yr. control was $164,400,000 in addition to the $34,080,000 granted to the mining industry in connection with the strike of 1921. This enabled the government to fix the price of coal during the war for home consumption and to the allies, but such a course would hardly be warranted in times of peace.



The Worst Breakdown I Ever Encountered

THE WORST breakdown I ever encountered was a cracked astern column of the intermediate engine. The only solid portion was a length of 8 in. at the back. The main was a triple expansion inverted engine. Diameter of intermediate cylinder was 28 in., stroke 24 in., 120 r.p.m., steam pressure in intermediate steam chest about 50 lb. The column was 1 in. thick throughout. The crosshead drove the rocking beam for working the back pumps, i. e., bilge, feed, air and circulating pumps. The lubrication for the guides consisted of a connection from the oil box to the top of the guide, and at its bottom it had a trough filled with water and oil. The slipper had at its bottom fastened a brass comb plate, the tips



DETAILS OF BROKEN COLUMN

slightly bent out purposely to pick up the lubricant on its upstroke. The oil ways on the surface of the guides were recessed circles ¼ in. wide and about 2 in. diameter, located as shown in the accompanying sketch.

Being in port, in the morning, the second engineer allotted certain work for me to do. While he went ahead and started to adjust the medium pressure engine slippers, I was occupied in my work and was not paying keen attention while he was proceeding with his work; only I had an idea that he really lined up the slippers while the engine was at the bottom center. (The way that they should have been adjusted was to bring the engine to the top center, center the piston rod, and line up accordingly, leaving about 0.005 in. clearance. This clearance will be more when the cylinders are warmed up, on account of expansion.) Not being assured, I discarded the idea and when both of us finished our respective jobs, we got everything tidied up for sea that evening.

The second took a few turns of the engine and was satisfied that everything was O. K. Then we received orders to stand by and gradually brought up the engine to full speed—8½ knots. The chief and I went after the second passed the word "All right" to take our tea. After 20 min. an oiler came down the mess room breathless and told the chief that the second wanted him and there was trouble. Down we hurried and saw the medium pressure engine all in flames and the second shouting like a maniac. The following is a brief summary of the cause of the breakdown:

The second lined up the slippers on the bottom center, and did not provide sufficient clearance. (The guides when cold are not parallel but tapered, and they are rendered parallel when warmed up.) When the engine was brought up to full speed excessive friction was taking place, consequently the head slipper had smoked on him and lost ¾ in. of its babbit metal. Afterwards the astern slipper started heating up and lost all its babbit metal. Lubrication was impossible and consequently the guide became cherry red, so did the slipper. The second squirted some oil with a syringe on the red-hot column (which line can be traced by the crack) and suddenly cooled the part, being cast iron, and the engine going up on the top stroke; therefore putting the column under tensile stress caused the column to crack round as shown. Further lubrication in contact with the heated metal made the oil burst into flames. This was the condition of the engine when the chief and I came down the bottom platform. We proceeded to fix matters temporarily. We had no tools aboard to do the babbiting, so the chief engineer suggested filling up the same space in the slippers' working surfaces with two layers of ⅛-in. hard drawn brass plates. We cleaned out the babbit metal of both slippers, refreshened the stud holes where the metal was held taut, fitted the plates in the place as shown, put in ⅝-in. brass studs, countersunk the holes in the top plates and riveted them over flush and cut the oil ways. As regards the crack we drilled ¼-in. holes at the terminations of the crack to prevent further spreading, and put on patches as shown, being of ⅜-in. steel plates, held on with ½-in. steel tapping machined bolts so as to compensate and secure the crack against any sudden shocks and the engine's working load. When the column cracked the top part projected out 1/16 in., which had to be chipped flush. The surfaces of the guides were case-hardened and we had to use many a chisel and file on the job. We slipped on the slippers, gave the required clearance while on the top center and tightened it up.

We went to sea and did an average speed of six knots. We were fortunate to be blessed with calm weather. That trip took us six days and when tied to the wharf, we ordered a new column immediately to be made.

EDWARD B. FLAHERTY.

A Costly Oversight

In a power plant consisting of two 250-kv.a. synchronous motor generator sets supplying 45 per cent of total load and transformers supplying the remaining 55 per cent to a load of combined induction motors and lights, the power factor was assumed to be at least 85 per cent although no meters were installed, other than those on the motor generator sets, and these were kept on the lead side, close to unity. A short time ago the central service station installed a kilowatt-hour meter and a wattless current meter, these showing a power factor of 62½ per cent on total load, at the end of the month, which rather upset our calculations, and incidentally, our pocketbook, when the penalty bill for all under 85 per cent power factor came along. As the plant was well designed throughout, we looked in vain for trouble that would lead to low power factor and as a last resort, went after the power factor meters on the motor generator sets, which had been installed by the manufacturer and found them hooked up backwards.

We had been accustomed to hold the excitation on the motor generator sets at 40 to 42 amp. which meant a unity power factor for them.

Now, we keep them at 58 amp. and hold the central station service wattless current meter at a standstill, giving us a leading power factor of 85 per cent on motor generator sets, but a unity power factor on combined synchronous and inductive loads.

In this case, the over-excited fields of alternators act as a synchronous condenser, and incidentally save a few hundred dollars each month, as a discount is allowed for all over 85 per cent power factor. Wm. Morton.

Our Mistakes

A disagreeable detail in the business of inspecting is that of showing up the other fellow's mistakes, and it is surprising just how bad some of these mistakes are.

Some time ago I was sent to the northern part of the State of Maine to inspect an old boiler that was for sale. I was met at the station by the superintendent of the plant I was to visit, and later I found that this gentleman was also the chief engineer of the plant. We had a 10-mi. ride, and throughout this ride he talked upon nothing but the boiler, and the great things he had done to it. He informed me eight times during our trip that he was willing to guarantee the boiler for a pressure of 125 lb.

Arriving at the plant, I was at once escorted to the boiler which was on blocking in the mill yard, and one look at it was enough for me.

This boiler, which was of the three course return tubular type, had been badly bagged in the first course. Mr. Superintendent therefore had secured the service of the local blacksmith and had had the first course cut away, and a new course was installed, with a single riveted lap joint. The original design of joint given the boiler was a butt and strap double riveted, with the two straps of the same width.

This was a 72-in. boiler and based on the age and general construction was good for about 30 lb. pressure. Figuring on the data given in the sketch showing the boiler, Fig. 1, allows the boiler 38 lb. pressure. I spent 2 hr. trying to show the superintendent why this boiler could not carry more pressure, but he couldn't see it.

Figure 2 shows an attempt that was made to strengthen a boiler joint. A is the original joint, and in this joint the weakest part is the net section between the rivets. B is the same joint with a plate added. In joint B the failure is the same as in joint A. The mistake here is in pitching the rivets the same in the outer row as in the inner row.

About 2 yr. ago, I was sent to Maine to inspect a boiler that had been badly burned in a large paper mill. Investigating the matter brought to light the fact that the boiler (an old style Stirling) had been flooded with wood pulp, which plugged up everything, letting the boiler run dry. In this case, a freak piping system was to blame. This piping is plainly shown in Fig. 3, and here is what happened. The fireman was feeding water to No. 1 boiler through valves C and A. The digester man opened valve B, without ascertaining

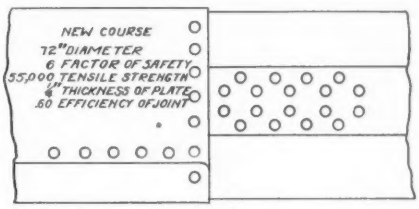


FIG. 1

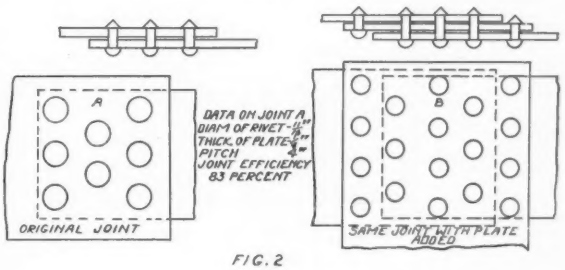


FIG. 2

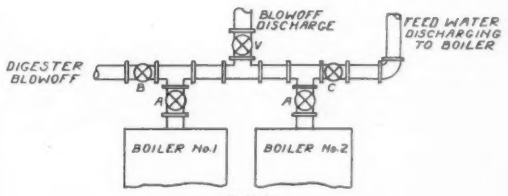


FIG. 3

FIG. 1. SINGLE LAP RIVETED JOINT PUT ON BOILER ORIGINALLY HAD DOUBLE RIVETED BUTT AND STRAP JOINT

FIG. 2. ATTEMPT MADE TO STRENGTHEN JOINT BY ADDING A PLATE

FIG. 3. BLOWOFF PIPING WHICH CAUSED BOILER TO BURN

whether valve V was open or what the fireman was doing, and of course the feed water carried the wood pulp into the boiler. In this particular case, there was no justifiable reason for piping the digester blowoff to the same line as the boiler blowoff, except to save about 100 ft. of 4-in. pipe.

Not very long ago I was asked to investigate the why and wherefore of a marked increase in the fuel consumption in a local plant. I looked the proposition over carefully, and could find nothing to justify the increase. In talking with the fireman, however, I was informed that the company's mechanical engineer had, just before the fuel supply increase had been noted, recommended

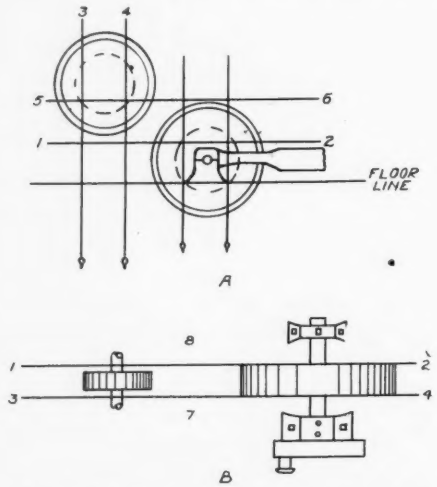
that the exhaust steam from a condenser drive be turned into a low pressure turbine supply; a turbine, by the way, that already had plenty of steam for its work. This exhaust from the condenser drive had previously been used in an open heater. Right away I saw the trouble, but when I made my report to the office, I was ridiculed. I settled this by demanding a practical demonstration. With the condenser drive exhausting to the turbine intake, we had a feed water temperature of 145 deg. and with the exhaust going to the heater, we had a feed water temperature of 250 deg., practically a saving of 10 per cent in the fuel consumption. Possibly if thermometers had been supplied in the feed lines someone else would have detected the trouble.

A. D. Palmer.

Lining Up

Nearly everyone has had trouble with belts running to one side of pulleys, generally because either the driver or driven pulley has not been properly lined to each other. In ordinary positions, this may be done easily but other times different methods must be used. The case at hand we will say is where the shafting is in another room from the engine, which drives it.

In the sketch, A shows an instance of lining up when the line cannot be run by the pulley rims. Two



METHOD OF LINING UP BELT PULLEYS

vertical plumb lines, 3 and 4, are run by the driven pulley, just touching the edges of rim. The line 1—2 is run by the plumb lines just touching them, both ends being fastened, of course. The distance between 1—2 and the flywheel rim will tell which way to swing the engine. Sometimes the engine wheel has a wider face than the driven wheel, then run the line 1—2 equally distant from the lines 3 and 4.

Where conditions make it impossible to line by the flywheel to lines 3 and 4, another line 5—6 is run as shown having equal space each side of pulley on main line shafting. Plumb lines should just touch 5—6. If plumb lines now touch the flywheel rim at top and bottom edges the pulleys are in line. Pulley having different widths, the distance 7 and 8, as at B, between pulley edge and lines should be equal. If the line just touches the flywheel on one side and is ½ in. off on the other side it means that the opposite end of the engine should be swung around one-half this distance or ¼ in. In case it is desired to line up jackshaft and engine if both are known to be plumb, it is only necessary to run lines as shown in B, 1-2,3-4.

Sam Bow.

Frozen Water Pipes

H. A. Jahnke in his article about thawing frozen lines (May 1 number) erred when he said that ice has much expanding power when heat is applied to it. This is not the law of physics; rather the opposite. Kent's figures show that water turning into solid form expands 8.55 per cent. In turning back to water again it shrinks that much, so it would seem that the breaking of a pipe or fitting filled with ice is not due to the greater expansion while thawing.

A line may be broken by the freezing or by the thawing. There are certain factors entering into it—whether it freezes quickly or slowly, whether the ends or the middle of a pocket is frozen first, whether the pipe is filled when it freezes or freezes as it leaks in, whether the metal is cast or wrought, whether in thawing excessive heat is applied in any one spot. When a line is frozen, it is possible that breaks are already there, though not evident because of no flow of the fluid. If not already broken, the line may be broken in the thawing, though not in the manner suggested by Mr. Jahnke.

When a line freezes slowly, the fluid expands along the length; the ice building from the metal in and with the room to expand, no great harm is done to the metal. When frozen quickly, the chances are that it freezes right through in some places and not in others; consequently, the rest of it in freezing expands across the section and the result is usually a break if the metal is cast metal. If the metal is wrought metal, it will stretch with the pressure, sometimes giving way, sometimes not, but in any event greatly straining the metal. If the wrought metal has not given way, the excessive heat of a torch will apply a greater stress to an already strained piece and the damage is done. If the middle of a pocket is frozen first, the expansion is along the length; if the ends are frozen first, the expansion is across the section. A line filled with water and freezing may result in several breaks along the line, the cast fittings going first; a line filling from a slow leak and freezing as it flows in, never breaks because the ice forms by building up and has plenty of room for expansion.

The heat of a torch or flame is too violent to an already overstrained metal. Hot water or the electric current is to be preferred, though the flame could be used if one understood the conditions of freezing and used the flame with care. One should first go over the line looking for breaks before starting to thaw; also for bulges and strained pieces. He can then see where he is to be careful, what will have to be broken out, how he can expedite the thawing. One should avoid setting up shocks on the line while frozen, because pieces under stress may give way under a sudden shock.

Patrick J. Downey.

Getting Around to It

No doubt we have all heard the story of the lark—or was it a dove?—who had her nest in a certain farmer's wheat field. As the story runs, she was not at all fright-

ened when she heard that the farmer had hired men to come and cut the wheat, rightly guessing that hired help could not be depended upon; and was still less frightened when she found that he had sent for his cousins to come and help him cut the grain, for she realized, as we all come to realize sooner or later, that relatives can't be depended upon either; but who fled in consternation when she discovered his intention to do the work himself, and none too soon, for the grain was harvested the next day.

Well, it strikes me that that farmer was a remarkably energetic man. Or perhaps he lived in those good old days when men really did the things they said they were going to do, and didn't wait a week or two for the thing to get behind time. Many of us in these days won't do a piece of work until it has accumulated and grown to its fullest size, then ripened for a time. In fact, usually it is put off until it cannot be put off any longer. The motto of some men would seem to be "Never do today what you can put off till tomorrow."

When you tell a man to do a piece of work he dreads to do, he frequently says, "All right, when I get around to it." Probably you have heard a man say "I'm going to put in a new hickey there as soon as I can get around to it."

This attitude is especially marked with regard to the installation of new machinery or equipment. If an engineer needs a new pump or fan, he will often wait for weeks, putting up with the inefficient operation of the old machine, just because he dreads the job of installing a new one.

I knew of a case once—a cotton gin in a small town in the heart of the cotton belt. There were two gins in the town. One was an old-fashioned steam gin arranged to burn wood. The company which operated it determined to change the installation so as to burn coal. This necessitated, among other things, a new stack. This was installed barely in time to begin working when the season opened.

The other gin had been similar in type to the first one, but as the engine and boiler were worn out it was decided to use an oil engine. The engine selected was amply large to run the gin, but they waited so long about ordering it that when the ginning season opened they had no engine. When it did come, more time had to be taken to unload and install it, and after that the engineer had to learn how to run it, so that they missed most of the ginning season. I doubt if they ginned more than 200 bales that fall, whereas the steam gin, by working day and night, probably ginned more than 3000. It was in 1919, when cotton was plentiful and brought a good price, and of course ginning brought a good price too, and the loss caused by delay was far from negligible.

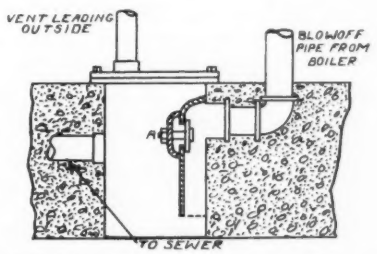
J. SMITH.

Peculiar Noise in Blowoff Tank

I HAVE HAD a boiler blowoff tank in use in my plant for a number of years. For some time I had noticed a peculiar noise in the tank whenever blowing out some of the dirty water in the boiler mornings and noons; but did not pay much attention to this, as I was under the impression that perhaps I opened the blowoff valve more at one time than at another, hence there was more noise in the blowoff tank.

The bottom blowoff from the water column is also connected into the blowoff tank and it is my practice to blow down the water column immediately after blowing down the boiler. Having the blowoff valve closed one morning while blowing out the water column, I noticed that the water would not disappear entirely from the gage glass with the valve wide open. I thought at that time that perhaps the disc in the column blowoff valve had come loose, as I knew that all pipes to the column were clear. To find what was wrong, I closed both valves in the water column connections and removed the bonnet from the blowoff valve, but found nothing amiss. After replacing the bonnet and opening both column connection valves, I opened the column blowoff valve again. All seemed to be clear, as the water disappeared entirely from the glass and returned quickly when closing the valve; hence, I was sure that there was nothing wrong with the water column connection.

But in thinking the matter over, I came to the conclusion that there was something wrong with the blowoff tank, this being clogged up. At the first opportunity the cover was removed, when it was found that the pipe from the tank to the sewer was partly stopped up, so that whenever the boiler was blown down and, as was my practice, the water column blow out immediately after this, the water had not all run out of the tank which caused a back pressure on the water column blowoff, so that the water would not all disappear out of the glass. During the time that I had the two column valves closed and bonnet taken off the column blowoff valve, the pressure and water had time to run out of the blowoff tank, causing a clear outlet again; then when I opened the column blowoff valve again after the bonnet was replaced the pipe between blowoff tank and sewer was clear so that there was no further trouble.

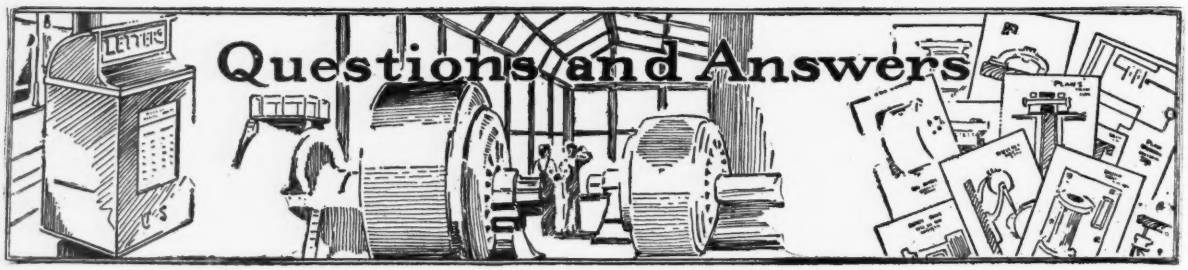


SECTION THROUGH BLOWOFF TANK SHOWING CAUSE OF NOISE

While having the cover off the blowoff tank, I also found the cause of the peculiar noise whenever blowing down the boiler. There is a handhole plate in the connection where the blowoff pipe connects into and reaches down below the water line in the tank as shown in the diagram at A. Due to some cause the nut in the handhole plate bolt got loose, which allowed the plate to drop out of position with the result that whenever blowing down the boiler, some of the water and steam would blow through the manhole opening instead of into the water space, as it should, causing the peculiar noise I had heard.

When the handhole plate was replaced and cover on blowoff tank in position, opening the boiler blowoff valve for a short time did not cause the noise, showing that the dropping out of place of the manhole plate was the cause.

H. A. JAHNKE.



Would Forced Draft Improve Conditions?

I AM in charge of two horizontal return tubular boilers of 80 and 120 hp. rated capacity, generating steam at 100 lb. pressure. We are equipped with a chimney that gives us a good natural draft.

Would there be any gain in economy in the amount of coal burned if we installed a forced draft system in place of the natural draft? We have to fire with inexperienced help and our coal is very expensive

M. O. B.

Condenser Questions

I RECENTLY WAS drawn into an argument over a question in which I believe some of the readers of Power Plant Engineering will be interested and upon which they may be able to offer some enlightenment.

What would be the result if a 1-in. hole was drilled in the tail pipe of a barometric condenser at the level of the hot well? The tail pipe is to be 8 in. in diameter and 34 ft. in height. The condenser is to syphon its own injection water.

In my opinion, a 1-in. hole at the level of the hot well would have no effect upon the vacuum and it would be impossible to flood the engine, provided the tail pipe was 34 ft. high. This would be true with the highest vacuum obtainable. In this case, a forced injection would have to be used in starting up. If now the hole was raised to a distance of 5 ft. above the level of hot well, the engine could easily be flooded with water. The atmospheric pressure would act on the water in the tail pipe at the point where the hole is located, in this case, 5 ft. above the hot well, and would elevate the water above this point due to the amount of vacuum in top of condenser. This would be sufficient to force water into engine. With 27 in. of vacuum in the top of the condenser the water would stand normally at 30.375 ft. With the extra 5 ft. elevation, which would equal 35.375, it is easily seen that water would go over to engine. The question is, would the air gradually work its way to top of condenser and destroy the vacuum or, would it go up in a slug as a solid piston? I consider that the latter would be the result.

A question was also asked, can this type of a condenser be started up when it has to raise its injection water 20 ft.? There is no cross pipe, no forced injection and no pumps on it.

In this case it is theoretically possible to weigh down the vacuum breaker and start the engine and let exhaust steam into condenser to blow out air and other noncondensible vapors into hot well. If the engine is down the steam in the condenser will condense and form a partial vacuum which is sufficient to pick up the injection water. After the water is once picked up it will keep on syphoning until the vacuum is broken. I consider that the condenser could not be started as stated above under practical conditions, due to unavoidable leaks about the condenser or engine.

These questions were asked by Massachusetts examiners for engineers license and I would greatly appreciate comments from readers on this subject.

F. W. R.

Drawing Up Flange Bolts

IN HIS question on drawing up pipe flange bolts in the June 1 issue, O. L. W. does not state whether his gaskets are cut to fit inside the bolt holes, or if they are the full size of the flanges with holes cut out for the bolts. He also says nothing about the material from which they are made.

For the service mentioned, they should be of some material which will withstand high temperatures such as asbestos sheet, or some of the combination copper-asbestos gaskets. In either case they should be cut to fit inside the bolt circle. The flange faces should, of course, be perfectly clean and parallel (the center lines of the two sections of piping or fittings should form one straight line).

In drawing up flanges, the writer has had a considerable degree of success with the following method: Draw the flanges together with two opposite bolts, alternating between the two and drawing only a small amount on each one at a time until they are rather a "snug pull"; the remaining bolts are then drawn up in the same manner after the nuts are tight enough to require the use of a wrench, the main point of this system being to draw up on a bolt which is directly opposite the last one drawn up.

It is a good idea to follow up the flanges after they become hot, although flanges drawn up in the manner just described have been known to hold perfectly tight for several months.

OPERATOR.

IN REPLY to O. L. W.'s question as to the proper method of drawing up flange bolts on high pressure piping, I would like to suggest the following:

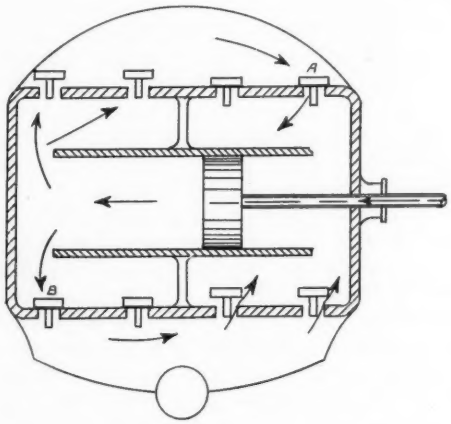
In this plant and all the others I have been employed in, the method that was used was to take four opposite bolts and draw them up tight and evenly; then follow around with each bolt until they are all tight. If the piping is warm and the flanges come together, the bolts may be drawn as tight as possible; but if the piping is cold, it is best not to draw it too tightly until the pipe is warmed up; if the bolts are drawn up tight, however, there should be no necessity of following up afterward and there should be no trouble from leaking joints

unless the piping is not lined up correctly. If O. L. W. will follow this plan, I think he will have no more trouble from leaking joints. D. G. SIMMONS.

Cause of Quick Return Action on Feed Pump

QUICK RETURN action on a feed pump, mentioned by P. B. in the June 1 issue, may be caused by defective suction, or discharge valves. The best way to locate the trouble is to open up the pump.

In the accompanying sketch, suppose the plunger is moving in direction shown by the arrow, if the discharge valve A is broken or if there is some foreign object holding it from its seat, water will flow back through it, under pressure, and tend to make the plunger move faster. Or if a suction valve, B, is defective; the water will flow through it into the suction pipe, thus relieving the pressure on this side of the plunger, instead of forcing the water through the discharge valves at this end. TOM JONES.



SECTION THROUGH WATER CYLINDER SHOWING HOW DEFECTIVE VALVES MAY CAUSE QUICK RETURN ACTION

I SHOULD LIKE to cite a little experience I had lately with regard to the same trouble. A sudden stroke toward the head end is caused either by a defective suction valve in the head end or by a defective discharge valve in the yoke end. One of my duplex pumps had a sudden stroke towards the yoke end. After putting the valves in shape I thought I had gotten rid of the trouble, but on running the pump again the same trouble appeared. Taking out the water cylinder on the defective side I found the trouble. The gasket around the barrel was almost entirely gone; this, of course, caused the slippage. After putting in a new gasket the trouble disappeared. JOHN PREUSS.

REFERRING TO the question by P. B. in the June 1 issue, as to what causes the quick return stroke on a pump, I should say that if the quick return is on the stroke toward the steam end, it is caused by a leaking discharge valve on the head end or suction valve on the crank end. If a discharge valve, the water follows the piston; if a suction valve, the water is forced back into the suction line. R. L. MOSSMAN.

Would the Installation of a Condenser Be Advisable?

I WOULD like an opinion as to the economy of adding a condenser to a simple double eccentric engine for summer use only. We have an excellent opportunity here, having a pond directly beside us from which we supply a water wheel.

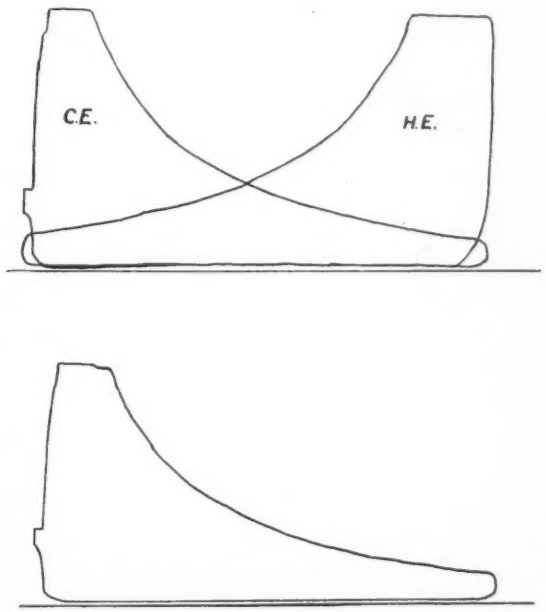
My idea is this: By arranging a bank of pipes in the flume, which is plenty large enough, and connecting return to a vacuum pump and maintaining say 18 to 20 in. vacuum, a substantial gain might be expected.

What increase in relative economy might we expect?

R. H. S.

What Is Wrong With This Engine?

THE ACCOMPANYING indicator diagram was taken from a 24 by 20-in., 60-r.p.m. Corliss engine using steam at a boiler pressure of 115 lb. gage. The crank end card has me guessing. What could possibly be the cause of the queer looking compression and admission lines? I would like to have the opinion of Power Plant Engineering readers on this question.



INDICATOR DIAGRAM FROM A CORLISS ENGINE

Inductive Interference

WE HAVE a small plant, several miles distant from our main plant. At times we deliver power to them and at other times we take power from them. We also have a telephone line that runs on the same poles under the 11,000-v. line. When we are delivering power to them, I can hear over the phone very well; but when we are taking power from them, it is difficult to hear them. What is the reason for this phenomenon?

G. H. M.

ACCORDING TO a Washington item, 56 per cent of the coal mined in the United States is machine mined.

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Operation the Test of Design

It is not at all uncommon, in visiting a power plant, to find that those in charge of operation have added to or changed somewhat the equipment as supplied by the manufacturer. The idea may have been original with somebody in the plant or it may have come from some competing equipment; but if it is a real improvement, *i.e.*, improves reliability, efficiency, safety, lessens work, etc., the industry has been benefited just that much, and the improvement should, if possible, be incorporated in the standard design.

Happily the day is fast disappearing when the designer of a manufactured device resents constructive criticism of his product. He realizes that the men who live with, watch and operate day after day the equipment he has designed, perhaps alongside of competing equipment, have an enviable opportunity to study its operation under all kinds of varying conditions and to make suggestions which would be real improvements.

Probably more than any other one influence responsible for recent developments in the design of power plant machinery is the close co-operation which exists between the engineers of manufacturing concerns and those who have charge of power plant operation. This is witnessed in the meeting of such organizations as the National Electric Light Association, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers where the needs of the industry are discussed and opinions on various solutions offered for overcoming difficulties are exchanged.

In the report of the Prime Movers' Committee of the N. E. L. A., a resume of which appears on other pages of this issue, for example, are enumerated not only recent changes in design of practically all kinds of equipment used in the generation of power, but changes in operating practice, the failures of certain details of designs, the special needs of the industry and many other points of interest and value to those in charge of power plants particularly, but also of great aid to the manufacturers in interpreting the trend of the times.

As the principal unit equipment of power plants becomes larger and more expensive the importance of correct design grows, and in such cases a special design is usually resorted to in which all engineers interested should have an opportunity of discussing with the designer the various details of construction and materials used and watching the progress of its construction through the factory. For such equipment as 35,000-kw. turbo generators or 2000-hp. boilers are not manufactured in the sense that they have become standard throughout and put out in quantities for stock purposes, but more correctly speaking, are usually constructed, being specially designed and built on contract for a particular installation. Their importance demands the utmost care throughout from original design to acceptance tests. Those engineers who will have charge of operation can, in many instances, suggest changes in details of design which will result in more satisfactory equipment and in the interest of progress should be adopted.

In this day of specialization only a few have been given the advantage of thorough operating experience together with designing and noteworthy advance in the

industry must depend more and more upon co-operation of all engineers in the field. It is the continued test of operation which proves the success or failure of a design, and the designer must know the difficulties met by the operator in order that improvements may be made.

The Auto-Transformer

The ordinary static transformer as used in the electrical industry today is probably the most perfect commercial converter of energy that we have available. In view of this fact, it may appear paradoxical to attempt to explain the action of a piece of apparatus which in certain cases is even more efficient than the ordinary two winding transformer. The auto-transformer or balance coil, however, must not be considered as something different from the ordinary transformer, but merely as a special type of transformer, and when viewed in this light, all confusion in regard to relative efficiency should disappear.

The auto-transformer is really a single circuit transformer in which the primary and secondary circuits are combined in one winding. Their advantages for certain purposes in alternating current work is so marked that their use has become standard. As balance coils, they are useful in alternating current distribution work for obtaining 110-v. lighting current from circuits operating at voltages of 220 and 440. When used for producing low voltage, high ampere currents in the starting of induction motors, they are called compensators. In either case, however, the principle of action is the same.

In the two winding transformer, the power transformed is the same as the power output. This, however, is not so for the auto-transformer. As pointed out by Frank C. Vogen in the series of articles entitled "Auto-transformers," of which the first appears in this issue, the power transformed in the case of the balance coil is always less than the power output.

The size of the auto-transformer for a given voltage, furthermore, varies in direct proportion to the power transformed. If it is possible, therefore, to obtain a given output without transforming all of the power a saving will result.

In connection with the use of the auto-transformer as a balance coil on 220-110 v. 3 wire lighting systems it may be well to call attention to the savings that may be effected by the use of 110 v. lamps instead of the 220 v. type. A comparison of lamp ratings shows that the 220 v. lamp—whether carbon or tungsten—has a much lower efficiency than the 110 v. lamp. The cost of the 220 v. lamp is also greater than the 110 v. type and is more or less difficult to secure, particularly in the smaller sizes. In many installations, therefore, where 220 v. incandescent lamps are used, a careful analysis will often indicate that an appreciable saving may be effected by the installation of a balance coil and the replacement of the 220 v. lamps by 110 v. lamps.

The principle involved and the methods of calculation used in the application of the balance coil are explained by Mr. Vogan in a simple and straightforward manner, and the articles it is hoped will give the operating man a clearer insight into this very useful piece of electrical apparatus.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.

Develop Water Power Sites.

Promote Health and Safety in Power Plants.

Handle Coal and Ashes Mechanically.

Employ Engineers for Engineering Work.

If I Were a Coal Passer

If I were employed at a power plant along with other employes for no other purpose than to shovel coal and ashes, I'd let the big boss know that he had a real man on the job, a man with useful powers of observation, with initiative, with an eye out for economy, one who could pick a good workman, a man qualified to hold a better job.

First of all, I would get me a pocket notebook and I would keep track of all the work I did and how long I was at it. The number of every car of coal I worked on would go down in that book, also the kind of car and railroad compay it belonged to. I'd put down what kind of coal was in that car and what I thought of its condition—full of stones, wet or dry, dirty, covered with snow, frozen, evidence of leaky car. I'd rig up a chute that would save me steps in storing the coal and keep it from breaking to pieces. I'd learn how to store that coal so it would not ignite spontaneously and I would put my rules down in my little book.

As I wheeled the coal into the boiler room I would carefully weigh each load and make a note of this weight. I'd see if that wheelbarrow could not be improved by balancing the load more closely over the wheel, thus making it easier to carry even bigger loads. When wheeling out the ashes, I would weigh them and I would note my impression of them, too, particularly the amount of coke in them and the clinkers.

I'd make a note of who worked with me on any of these jobs and if anybody was quitting I'd have somebody in mind to take that place and see that he got to the proper man for employment.

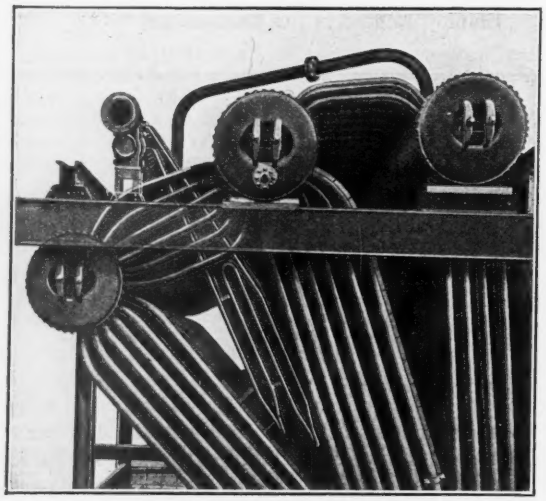
At the end of each week, I would spend an evening at home making up a nice clean condensed report of what I had done, my observations and what I would like to see done which would help me in my work, giving me time to do something else for which the plant pays more money than it does to coal passers. This report I would hand to the big boss personally while he was in his office.

I'd pick out the job next step higher up that I wanted and ask the boss how I could work myself into it. Then I'd pay the price by meeting his requirements and then I'd remind him to give me the opportunity I had earned. If I did all this, do you think I would be a coal passer very long?

This is no reflection on the coal passer, for to get anywhere we must start at some point and the reason none of us get where we might is that we don't do the best we know how.

Elesco Superheater

THE SUPERHEATER CO. has recently incorporated a number of new features in the design of the Elesco superheater which represent noteworthy advance in superheater design. Some of the points aimed at in this design are safety in operation, accessibility for inspection and repair, protection against



APPLICATION OF ELESCO SUPERHEATER TO VERTICAL WATER TUBE BOILER

overheating, use of high steam velocity, provision for expansion and contraction, and provision for cleaning.

This unit consists in general of two headers, one acting as a distributor for the saturated steam and the other as a collector for the superheated steam. The steam flow is in the same direction in both headers so that there is no tendency for the steam to be short-circuited around any of the elements.

The headers, in the majority of cases, are located outside the boiler setting proper so that they as well as the unit joints are accessible for inspection without entering the setting. Each header is reinforced along its length by a steel bar, milled along one side to fit the inside of the header. This bar adds the necessary material to provide sufficient grip for the holding studs, it is dotted along its length at points registering with the element connections.

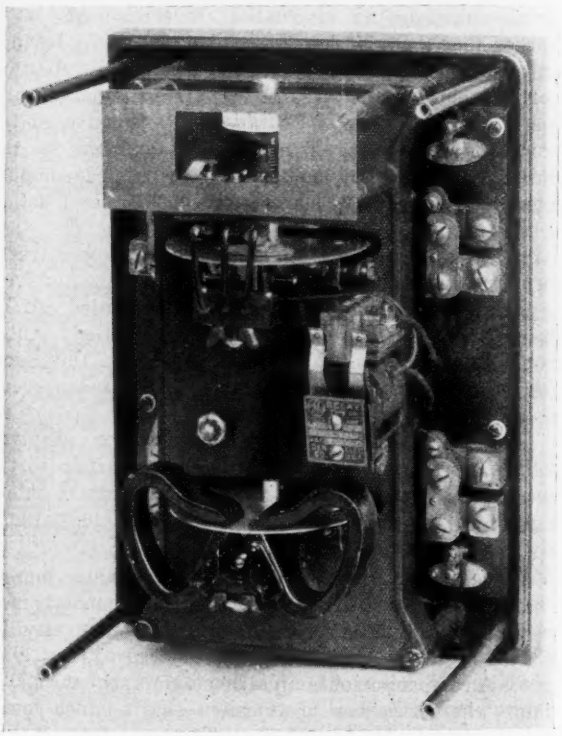
Each element is fitted with a ball joint that is formed integral with the tube by a forging process. This ball fits into a socket in the header and is held in place by a clamp which is held in place by a single stud screwed into the header.

Over-Power Induction Relay

AN INDUCTION relay for use on alternating current circuits to indicate when a predetermined load has been exceeded has recently been developed by the General Electric Co., and is known as the type IG-3. It may be used either simply to indicate an overload by sounding an alarm, or, in connection with another relay, to disconnect the alternator from the line. It is not provided with any time delay features, but these may be supplied by the use of a definite time limit relay in conjunction with it.

In appearance the relay resembles a watthour meter, being fitted with a dust-proof cover that is easily removable to permit inspection. The operating mechanism consists of a vertical shaft equipped with two disks, and mounted on jewel bearings. The disks are each driven by separate driving elements consisting of current and potential coils. The contacts are double throw, one side being the over-watt and the other the under-watt connection. The over-watt side actuates an auxiliary relay located inside the cover of the induction relay, and the under-watt side short-circuits the coil of this auxiliary, allowing it to open. In this manner, the main contacts of the relay are relieved of the tripping current.

In operation, the torque which is produced on the disks by the driving elements, and tends to drive them in the over-watt direction is opposed by a spring which produces torque in the opposite direction. When conditions on the line are normal, the torque of the spring is greater than that of the driving elements, so that



TYPE IG-3 INDUCTION POLYPHASE POWER RELAYS

the under-watt contacts are closed. Should the load exceed the amount for which the relay is set, the torque imposed by the driving element exceeds, and overcomes that of the spring, and rotates the disks in the over-watt direction, until the contacts close on that side.

This closing of the main contacts actuates the coil of the auxiliary relay, which closes, relieving the main contacts of the induction relay of the tripping or indicating current. The contact circuit of the relay can be used, by means of a definite time relay, or several relays in series, to cut the machine off the line, sound

an alarm that a given operation will take place in a certain time if load conditions are not changed, or perform any number of operations in a given sequence. Upon a reduction of the overload by about 25 w., secondary, the torque of the spring overcame that of the driving elements, causing the main contacts to close on the under-watt side. This shorts the coil of the auxiliary relay, and it opens, opening the circuit through the time limit relays in series. If these relays have not operated, they are automatically reset without functioning.

For setting the IG-3 relay to operate at the desired load there is provided a pointer, and a scale which reads in secondary kilowatts. The pointer is turned to the desired position on the scale by inserting a screw driver into a slotted sleeve just below the relay cover. To determine this setting in terms of primary kilowatts, the formula $\frac{KVA}{P \times R_1 \times R_2}$ or $\frac{KW}{R_1 \times R_2}$ is used, where P = power factor, R_1 = the current transformer ratio, and R_2 = the potential transformer ratio. The potential coils are intended to operate on 110 v., while the current coils have a current carrying capacity of 5 amp. The scale is usually calibrated from 0.5 to 1 kw. secondary.

Green Forced Draft Chain Grate Stoker

THE GREEN forced draft chain grate stoker which is illustrated here and designed for burning bituminous coals, represents a new design in the forced draft chain grate field. It has been under observation for several months at the Mill Street Station of the Indianapolis Light & Heat Co., where it has been tried under every variation of central station conditions.

Each of the five active compartments is entered by a door and is large enough to permit a man to crawl through from one side of the stoker to the other. This accessibility makes it practical to carry out much desired inspection of all air seals and the internal conditions of the stoker.

Air space in the chain is practically the same as in natural draft stokers. This permits natural draft operation up to 150 per cent of rating.

In designing this stoker and furnace, the manufacturer has recognized maintenance as one of the vital points to be considered in connection with the high ratings sometimes necessary in the central station field. To

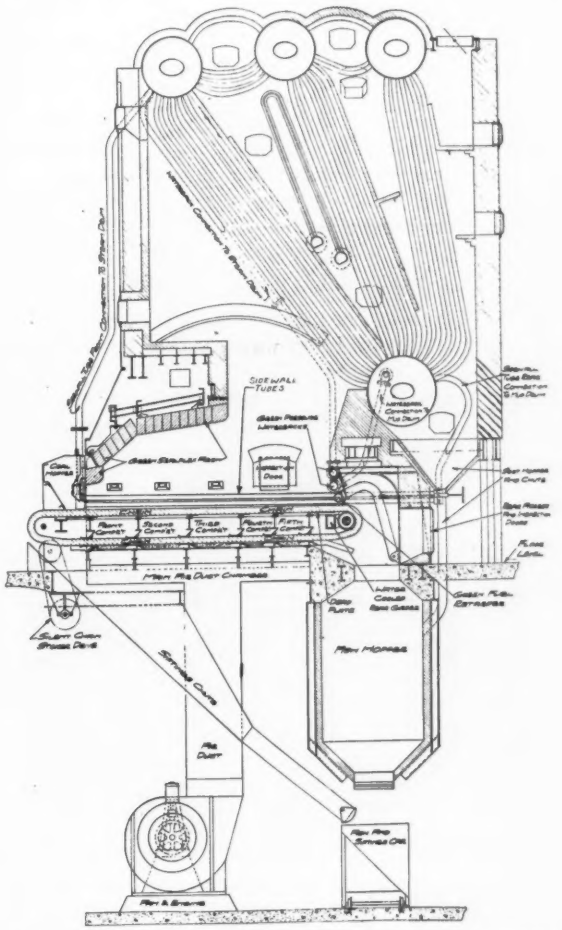


FIG. 2. APPLICATION OF NEW GREEN STOKER TO VERTICAL WATER-TUBE BOILER

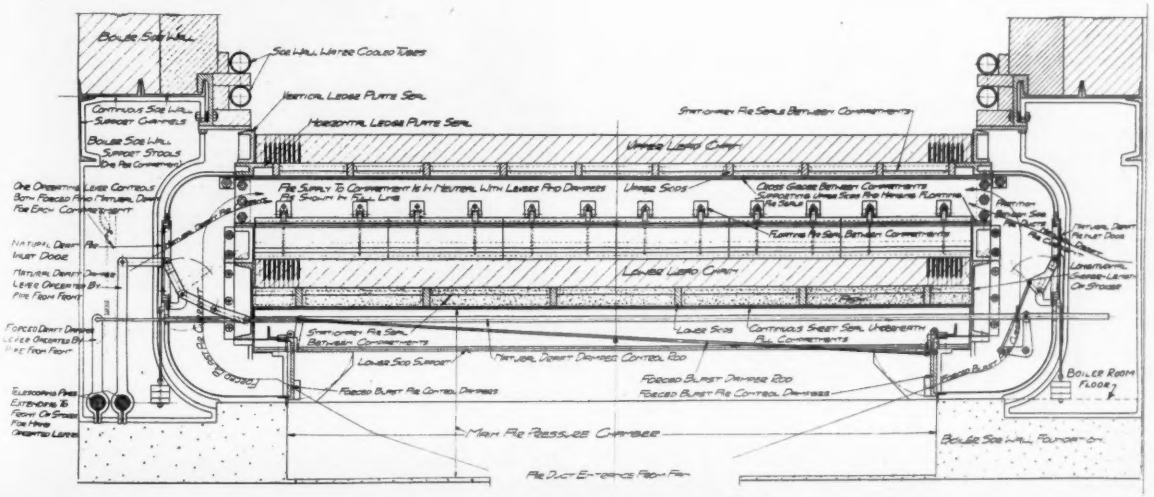


FIG. 1. CROSS SECTION OF GREEN FORCED DRAFT CHAIN GRATE STOKER

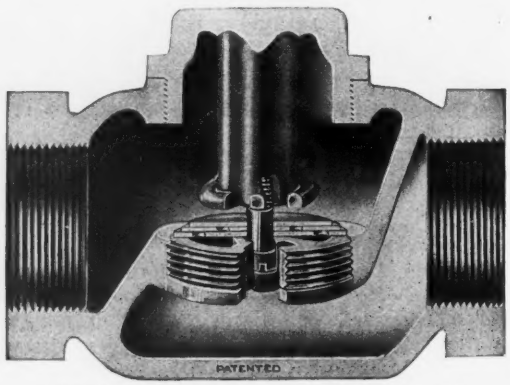
offset the known deterioration of sidewall brickwork at high ratings, the forced draft fuel bed is surrounded on both sides and at the rear by water-cooled members. Sidewall tubes protect the sidewalls; waterbacks and fuel retarders seal the rear and protect the bridgewall overhang. The Sealflex arch used with forced draft is designed to give the highest possible ignition rate compatible with low maintenance.

Air is supplied from the bottom for forced draft operation, thus leaving the firing aisles entirely free of obstructions.

In practical operation, the stoker has met every demand for flexibility in carrying the load. Firing rates up to 150 per cent of boiler rating are carried with natural draft, while extreme high rates under forced draft are available at all times.

Corry Check Valve

TO ELIMINATE all shocks when opening and closing, thus avoiding water hammer and reducing wear, this valve is made with three thin discs, two of them perforated, and a grooved striking base on the cap. The discs, carried by a guide pin, are ground true



SECTIONAL VIEW OF CORRY CHECK VALVE

to give a perfect fit both on the removable seat and on each other. Seat and discs are of bronze. Perforations and grooves give the desired cushioning effect, and the flat seats prevent any possibility of sticking. The valve is made by the Corry Valve Co., Corry, Pa.

Arc Welding Squirrel Cage Rotors of Induction Motors

MANY INDUCTION motors using squirrel cage rotors are constructed by bolting the crossbars of the squirrel cage winding to the end rings, the end rings being tapped, and the bolts being of the cap screw type held in position by means of lock washers under the heads of the bolts.

In other rotors, ordinary machine bolts are used with a nut on the inside of the end ring, the nut being held in position by means of a lock washer. In spite of the use of lock washers in this form of construction, the bolts have a marked tendency to work loose in service, and therefore some method of securing the crossbars to the end rings permanently is very desirable, especially for small repair shops where these motors are frequently taken to be overhauled.

The crossbars are high grade copper, whereas the end rings are usually an alloy of copper, designed to produce the proper amount of resistance in the squirrel cage winding, so as to give the motor the proper starting and operating torque characteristics. To weld these crossbars, therefore, to the end rings requires different materials and different manipulation from that ordinarily used in arc welding steel plate material and steel castings.

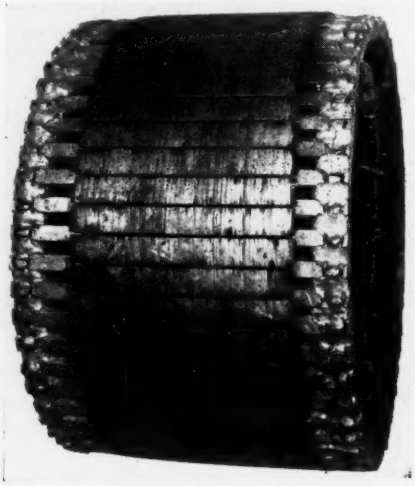


FIG. 1. ROTOR OF SMALL INDUCTION MOTOR SHOWING CROSS BARS WELDED TO END RINGS

Figure 1 shows a rotor for a small squirrel cage induction motor, containing 55 crossbars which have been welded to the end rings, leaving the steel bolts in position. To perform this welding work, the operator uses the graphite electrode process and a filler material of phosphor copper containing approximately 8 per cent phosphorous. The current value used is approximately 100 amp.

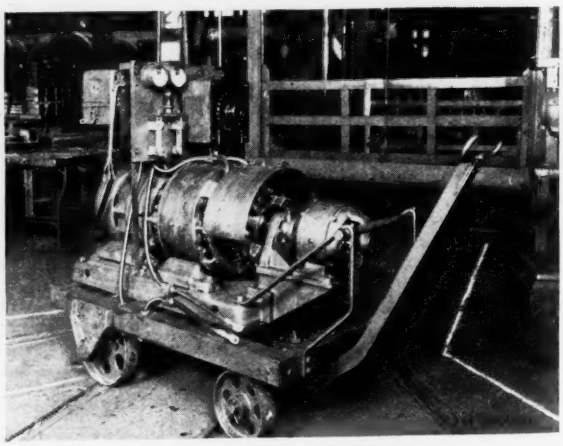


FIG. 2. WESTINGHOUSE PORTABLE ARC WELDING OUTFIT (SINGLE OPERATOR, 150 AMP.)

In performing this welding work it is found that, for properly forming a bond between the crossbar and the end rings, approximately one minute is required for the first two or three bars. At the end of that time, however, there is a sufficient amount of heat accumulated

in the crossbars and the end rings near the point where the welding is carried on, so that subsequent bars could be properly united with the end ring in approximately 30 sec. The entire welding operation, involving 110 welds, can be done in about 1½ hr.

In order to obtain satisfactory results with arc welding copper material of this type, it is necessary to use the phosphor copper material specified above in order to get the proper fluidity of the molten filler material, so that it will unite properly with both of the pieces to be welded together.

For carrying on welding work of this character, the welding outfit illustrated by Fig. 2 is usually used. Such an equipment as this is also adaptable for various other lines of repair work involving steel plate material, structural steel parts, steel castings, certain forms and types of cast iron castings, etc.

The Diamond Gage Cock

TO MEET the requirements for a practical and convenient weighted gage cock, the Cleveland Flue Cleaner Mfg. Co., Cleveland, Ohio, has placed on the market the Diamond gage cock shown in the illustration herewith.

This is of the weighted lever quick opening and self-closing type. The weight is diamond-shaped as shown at A and has in it a recess into which the star-wheel on the valve pencil, C, fits, the teeth of the star meshing with the projections in the recess of the weight.

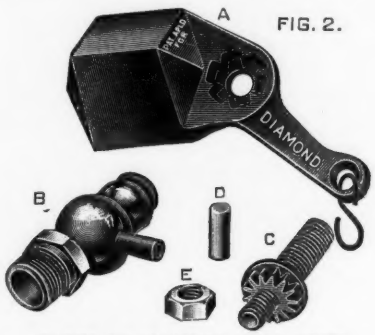


FIG. 2.

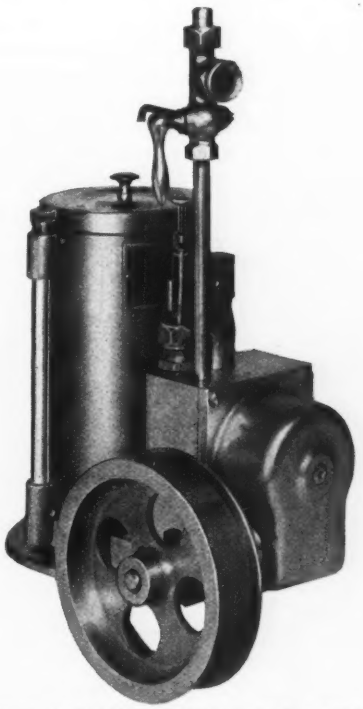
PARTS OF DIAMOND GAGE COCK

In this way the position of the pencil with regard to the weight can be adjusted without removing the weight from the stem. The pencil is screwed into the gage cock, B, which in turn is screwed into the water column or boiler head as the case may be. Nut, E, screws on the small end of the valve pencil, locking the weight onto the stem. D is the soft metal insert which goes into the larger end of the pencil and bears upon the gage cock seat, giving a tight joint.

Rotary Drive Lubricator

TO MEET the requirements of certain markets for a positive force feed lubricator operated by a pulley instead of a reciprocating arm, Greene Tweed & Co. has recently brought out a new design in oilers. It is adapted for the lubrication of the cylinders, stuffing boxes and bearings of steam and oil engines, pumps, compressors, etc., having a rotary member.

This model is operated by an inclosed and therefore dust-proof worm and gear. The worm is driven by a pulley which may be belted to either the main or lay



ROCHESTER AUTOMATIC ROTARY DRIVE LUBRICATOR

shaft of the engine which is to be lubricated. The apparatus is made with different gear reductions and can be operated with the pulley running in either direction. The amount of oil fed can be regulated to a great extent by altering the size of the pulleys used.

Bostong Reversible Pipe Wrench

IN EVERY power plant or wherever else there are pipes, it is frequently necessary to screw up or unscrew pipe joints. For this kind of work a good pipe wrench is indispensable. To supply the need for such a wrench, the Walworth Mfg. Co. has just placed

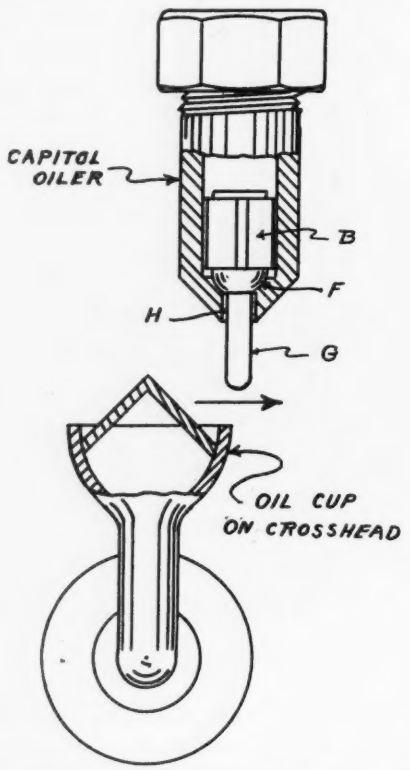
BOSTONG REVERSIBLE PIPE WRENCH

on the market its new Walworth-Bostong chain wrench shown in the accompanying illustration.

It is claimed for this tool that it insures a rapid and positive grip and release and that there is no lost motion in its application. The pipe may be turned either to the right or left, practically without readjustment of the chain or jaws. The chain is extra strong for the service and is tested up to two-thirds of the breaking strain. The holding pins and handle bolt are made of chrome alloy steel and are heat treated.

The Capitol Oiler

THIS convenient device, made by E. Winholt, of Moline, Ill., is designed to give regular, measured amounts of oil to moving parts of machinery. As shown in the illustration, it has a brass shell, threaded either inside or outside, as required, for attachment to the oil supply piping, inside of which is valve B, seating at F. Three oil channels at H allow oil to flow down around spindle G when the valve is lifted by the contact piece on the moving part, this oil being delivered to a cup below the contact piece. The amount of oil delivered



CROSS SECTION OF CAPITOL OILER SHOWING PRINCIPLE OF ACTION

will be the same for each contact and can be regulated by adjustment of the time that the contact piece holds the valve open.

The device can also be used for feeding other liquids such as boiler compound by arranging suitable feed and delivery connections to the system.

Carrier Current Used to Control Distant Lighting Circuit

REPRESENTATIVES of the Associated Edison Companies were recent witnesses on an unusual demonstration of carrier current held at the plant of the Lynn (Mass.) Gas & Electric Co., in which superimposed high frequency current was used for the remote control of relays operating a street lighting circuit and other devices. The demonstration, which was carried out by engineers of the General Electric Co., was intended to show that carrier current could be made to control switches at a distance point traveling over the regular lighting lines without interfering in any way with the primary power transmission functions of the line.

From the Lynn Gas & Electric plant, the carrier current system successfully controlled two circuits at Little Nahant, four miles distant, and was made to operate 18 incandescent and two arc lamps on one of the circuits and two 1000-w. searchlights, two 500-w. floodlights and a pendant lantern on the other circuit.

In the sending station, a high frequency generator with vacuum tube unit was used to convert the ordinary 110-v., 60-cycle lighting current into power at the much higher carrier frequency. The output of this generator was then superimposed on the 4400-v. feeder line running to Little Nahant. This line travels underground for a mile and above ground for the remainder of the distance of four miles.

The relays in control of the two circuits were arranged to operate at different carrier current frequencies and could thus be made to operate separately by varying the carrier current frequency. The apparatus tested was turned off and on at the will of the operator in the central station at Lynn.

These tests were the second of importance carried out. The first ones took place last December and demonstrated the use of carrier current as a medium for communication between central stations, power plants and stations on a distributing system.

Since that time intensive development work has been carried on by the company's radio department, coupled with a large amount of research work by the research laboratory.

Although the system has not yet been perfected in all details, it was pointed out that enough preliminary work has been done to indicate practical advantages of the carrier current system first as an aid to the solution of the central station communication problem and, as the results of the recent tests, its extension into the operating field. It is stated that any number of relays can be operated by the carrier current, thus controlling a number of separate circuits for various purposes.

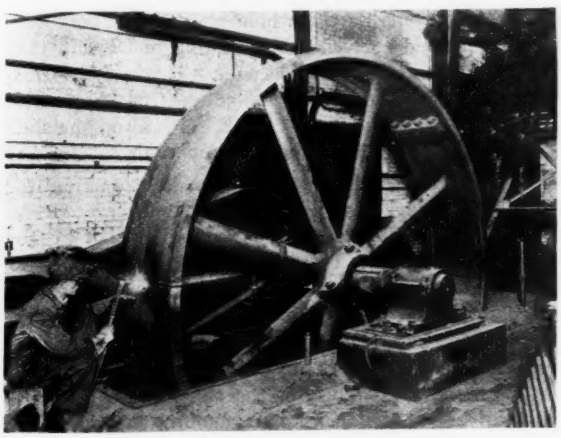
Sometimes Scrap Is Worth More

WHEN TO scrap and when not to scrap, is a question which occurs with surprising frequency in demolition work. At times there is a nice balance between the advantage of salvaging a piece of machinery or structural work and merely junking it. Since the development of cast iron cutting with oxy-acetylene, the practice in this branch of demolition has undergone a change, because it is now economical to reduce iron castings to charging box sizes in many instances where such a procedure could not have been considered a couple of years ago. This is particularly true in the cutting up of very heavy iron castings such as are found in the mechanical equipment of power plants.

An interesting case in point is illustrated in the instance of a Chicago malting company that recently contracted with a scrap metal company to dismantle a power plant containing a large cast-iron flywheel. Here the question arose as to whether it would be better to remove the flywheel in halves with a view to reassembling it as second-hand machinery, or to cut it up

into such sections that it might be easily removed and broken into charging box sizes for sale as scrap. Salvaging would have required the erection of a heavy scaffold, because the roof of the power house was not strong enough to allow the removal of the halves by means of block and tackle unless some supplementary support was provided. This would probably have been the procedure before cast iron cutting with oxy-acetylene was developed, because it would have been impracticable to break up the flywheel in place.

In the case noted, the cost of scaffolding and labor for removal and salvage would have approximated so nearly the resale value of the flywheel that its reduction to scrap resulted in saving a considerable sum, even at the present low price of cast-iron scrap. A picture of the service operator making the initial cut is shown herewith. There were eight cuts on the rim and one on each of the eight spokes. With the exception of the first



SCRAPPING LARGE FLYWHEEL WITH OXY-ACETYLENE TORCH

cut on the rim, all were made by the contractor's own operator after witnessing the service operator's demonstration.

This is specially interesting because of the fact that cast iron cutting is new to many users of oxy-acetylene who often overlook opportunities for making appreciable savings that one familiar with this development of the process would seize upon without hesitation.

One of the largest items of savings on the flywheel job just noted was time, the scrapping operation being accomplished in hours against several days which would have been required to remove the parts for salvaging.

Power Plant Is to Be Directed By Air Valves

A RADIO SYSTEM to tie the main office of the San Joaquin Light and Power Co. at Fresno to its scattered power houses is being installed and it is expected that the communication net will be completed before winter, when it will be mostly needed.

The organization of the power company, which centers about an official at the Fresno headquarters, whose duties correspond to those of a train dispatcher, makes quick communication necessary and winter storms have frequently crippled the telephone lines. The Fresno office constantly directs its power houses to increase or diminish their output of electricity to meet changing conditions of demand such as are occasioned by storms that darken the sky and by other conditions.

To enable the company official in charge of this department to reach his stations quickly radio is being installed by R. C. Denny, one of the company's electrical engineers. The ether waves will be more reliable than wire telephones and will make it possible for the officer at Fresno to control the electric output of the various power houses as effectively as a despatcher controls the movement of trains. With a central transmitting station at the Fresno headquarters and receiving sets at the power houses, a quick and certain connection is contemplated.

The company now has two radio-phone sets, one of 10 w., used exclusively for broadcasting entertainment three times a week, and another for experimental work. Mr. Denny is trying to develop an alternating current set with a filter system, which will eliminate the 60-cycle hum of the rectifier tubes. It is his purpose to produce a set which can be attached to the lighting circuits of the power houses so that an inexperienced person can attach and operate the set.

The action of the company in adopting radio as an aid to the conducting of its business is another example of the value of the new science to industry and demonstrates the wide usefulness which it holds. Broadcasting entertainments and news is the most spectacular form of radio work at present, but the San Joaquin Co. is among the large corporations taking it up as a commercially valuable development.

Standardization

ONE OF the most important ways of reducing costs of equipment and operation is to standardize machinery and methods. Secretary Hoover has instituted a widespread program for simplification of sizes and varieties of materials in general use such as paving bricks, axeheads, etc., and the work is now being carried on by the Division of Simplified Practice, Department of Commerce, headed by W. A. Durgin, formerly of the Commonwealth Edison Co.

Co-operating with this work is the American Engineering Standards Committee, organized in 1918 by four national engineering societies, which now has the assistance of 160 bodies of engineers and manufacturers, and to date 20 standards have been approved and 50 more are in process of development. To avoid conflict of activities, the Division of Simplified Practice will direct its attention to reducing the sizes and types of manufactured articles and materials for stock from which they are manufactured, while the Standards Committee will deal particularly with projects of special interest to engineering and associated industries.

Assistance of all engineers is requested in suggesting products, machinery and methods where simplification and standardization may well be applied. What may seem a minor change has often resulted in large saving when widely applied. This work is directly in line with such standards as pipe flanges and screw threads which have been developed by the Committee on Standardization of the A. S. M. E. in collaboration with other organizations, and the new work will have the hearty

co-operation of the A. S. M. E. through its committees, and by representation of the Standards Committee.

Suggestions may be sent to the Division of Simplified Practice, Department of Commerce, Washington, D. C., or if sent to Power Plant Engineering, they will be forwarded.

American Society of Heating and Ventilating Engineers Holds Convention

THIS SPRING the American Society of Heating and Ventilating Engineers held its semi-annual convention in Buffalo and Detroit during the week of June 5. The meeting opened in Buffalo Tuesday morning, June 6, at the Iroquois Hotel, with the customary address of welcome, and response by the president, which was followed by report of the committee on the fan testing code, furnace installation and guide publication.

Having thus disposed of the business at hand the rest of the day was devoted to the reading and discussion of technical papers. H. F. Hagen started the ball rolling with an analysis of modern fan design. This was followed by a paper by J. F. Caulderwood, A. J. Mack and C. J. Bradley, on comparative tests of automatic ventilators. Tests were made in a wind tunnel to determine the amount of air induced through various types of ventilators from a plain opening to the relatively complex rotary siphon type. The test indicated that the effectiveness of the apparatus placed them in the following order: Rotary siphon, plain rotary, stationary siphon, plain stationary, and no ventilator. The results also indicated a wide variation in the effectiveness of individual ventilators of each type.

A paper by W. S. Timmins presented a mass of formulas and data for the determination of water pipe sizes for various plumbing fixtures. It appears that heretofore such problems have been solved largely by rule-of-thumb methods with but indifferent success. The author urged the adoption of more scientific methods of procedure.

J. E. McDermet presented a paper on corrosion and its prevention in water carrying vessels in which he pointed out that, from a practical point of view, corrosion occurs only when water and air are present together and that to eliminate the trouble it is simply necessary to remove the air from the water. This may be done in a number of ways with varying degrees of economy. His recommendation, however, was the system of explosive boiling under vacuum on account of its relatively high thermal efficiency. This method he described in more or less detail.

Wednesday morning, the session opened with a paper on body temperatures and their measurements, by W. J. McConnell and F. C. Houghton, describing results obtained at the A. S. H. V. E. research laboratory at the U. S. Bureau of Mines at Pittsburgh. These experiments were conducted to determine the physiological effects of high temperatures and humidities on various types of workers.

Following this there were three papers on dust, its effect and determination. Standard methods of testing dust removal efficiencies of air washers by O. W. Armspach and Margaret Ingels; development of a new method of making air dust determinations, by F. Paul Anderson and O. W. Armspach; and dustiness of air in granite cutting plants, by S. H. Katz and L. J. Trostell. The last paper indicated the necessity of properly removing the dust incident to certain industrial operations to promote higher efficiency in the worker. The first two described methods of making the best determination. The old method of passing an air sample through water and then examining a film of the water under a microscope was found to require too much skill and to be otherwise unsatisfactory and a new method was developed. It consists simply of passing a known quantity of air through a filter cloth of a given area and measuring the pressure drop through the filter. Dust particles clog up the pores of the filter quite rapidly and hence the pressure drop increases. A measure of the dust content of the air may thus be obtained by noting the rate of increase of pressure through the screen.

Wednesday night, the whole group embarked on a lake steamer and arrived next morning in Detroit, there to take up where they had left off. Thursday morning H. W. Anderson presented an address on the Schools of Detroit. He was followed by E. V. Hill on the stand of the society on ventilation fundamentals.

The Friday morning session was devoted entirely to the consideration of pipe sizes. First there was the report of the committee on this subject, which was followed by a paper by F. C. Houghton and L. Ebin, on the capacity of steam heating mains as affected by critical velocities of condensate mixtures. A paper on critical velocities in one-pipe system, by F. E. Geiseke, and one on dry returns, by R. V. Frost, both had to deal with the same phase of the subject. The problem had to do with the maximum amount of condensation to be encountered and the determination of pipe sizes to suit these conditions. The problem involved the determination of a critical steam velocity, i. e., the velocity above which the returning condensate would be picked up by the steam and carried along in a slug to the radiator. Some interesting experiments were carried out along these lines which showed fairly consistent results. Under conditions normally obtaining in heating systems this velocity was found to be in the neighborhood of 20 ft. per sec.

J. E. Bolling, member of the guide publication committee, explained to the members the aims, functions, and accomplishments of the guide. The publication of the Heating and Ventilation Engineers Guide is a new undertaking of the society. It contains reference data useful in the design of heating apparatus compiled from various scattered sources of such information now available, a catalog and reference section and an equipment section. The publication of the first yearly issue was met with great enthusiasm and it is expected that the undertaking will prove most successful.

J. A. Donnelly's paper on temperature control by fractional distribution of steam was carried over to Saturday on account of the great amount of discussion which was forthcoming on the subject of critical velocities. This paper dealt with the individual radiator valve adjustment to produce equalized heating under various temperature conditions.

Following this there was a review of the recent devel-

opments in warm air furnace heating, by F. R. Still, which dealt largely with better proportioning of ducts as affecting the efficiency and capacity of an installation. Some mention was made also of the use of blowers for stimulating flow.

The subject of the dedication of true thermal conducting coefficients from overall test results was presented, from a mathematical point of view, by B. Nicholls. His object was to discover the accuracy of test results and to determine to what extent test results are applicable to actual conditions.

A description of the use of air conditioning apparatus for sausage manufacturing plants, by M. G. Harbula, closed the session.

During the stay in Detroit numerous inspection trips were arranged and as a rule well attended. A few of the places visited were the plants of the Detroit Edison Co., the River Rouge plant of the Ford Motor Co., the U. S. Radiator Co. plant and the Master Plumbers' Exhibit at the General Motors Bldg. Nor was the time all spent talking shop. There were baseball games, golf tournaments, dinner dances, and theatre parties in the afternoons and evenings, all of which were particularly well attended.

Samuel Naphtaly, Vice-President of Great Western Power Co., Dies

SAMUEL NAPHTALY, vice-president of the Great Western Power Co., of San Francisco, who for a score of years had been associated with the electrical development of California and who was one of the leaders of industry that in 1906, after fire had razed the city, energetically set about the plan of reconstruction, died, June 26, from heart failure at Adler Sanatorium.

Mr. Naphtaly was born in San Francisco, Dec. 20, 1874, and graduated from the University of California as an electrical engineer with the class of 1896, and from that time until March 20 of this year, when he had an attack of heart failure which sent him to the sanatorium, he had been active with several electrical companies and engineered some of California's greatest hydroelectric projects.

At the time of the fire in 1906, he was general manager of the San Francisco Gas and Electric Co., which later was absorbed by the Pacific Gas and Electric Co., and it was in this capacity that he did perhaps his greatest service to the city.

In the chaos that followed the fire, with all wires down and the generating plants destroyed, he performed a great feat when he hastily organized his workers and reopened the plants, repaired the lines and brought light again into the city. And it was through his efforts that the street lighting was extended into the Fillmore district in the period following the fire.

After several years at the head of the San Francisco Gas and Electric Co., Mr. Naphtaly became general manager of the City Electric Co., where he remained after it was taken over by the Great Western Power Co. in 1912.

One of the greatest achievements of engineering that remains as a monument to his genius is the Lake Almanor project in Plumas County, which was constructed in 1912 and which is today the chief reservoir of the Great Western Power Co.

Aside from his accomplishments in the electrical industry of the state, he was widely known for his connection with the Oakland & Antioch Railway, now known as the San Francisco & Sacramento Railroad Co., of which he was founder and first vice-president. In 1917 he organized the Los Angeles Shipbuilding and Dry Dock Co. of San Pedro, where he constructed cargo boats for war use.

Last January, he again entered the service of the Great Western Power Co. in San Francisco, and was vice-president and general manager until his health broke and he was forced to leave his work.

Pacific Gas & Electric Employes Hold 1922 Rally

TWENTY-FIVE HUNDRED members of Pacific Service Employes' Association, an organization whose membership is entirely from the ranks of the Pacific Gas & Electric Co., gathered at the San Francisco Exposition Auditorium the night of June 24 for the annual banquet of the association.

They came from all parts of the "Pacific Service" territory, from Shasta to Fresno on the south and on the east to the summit of Sierra Nevada Mountains. The dinner this year was the largest of its kind ever held in the west.

At the head table, W. M. Henderson of the gas department, San Francisco division chairman of the association, was supported by a number of officers and directors of the company, headed by President W. E. Creed and General Manager John A. Britton. At the long tables, which stretched to every corner of the room, the employes were seated by geographical divisions.

During the dinner a program of entertainment was furnished, and afterward addresses were made by Mr. Henderson, Mr. Britton and President Wigginton E. Creed.

News Notes

THE JUDICIARY COMMITTEE has completed hearings on the bill to limit the jurisdiction of United States courts in granting injunctions. Demand for the legislation comes from municipalities which want to remove from the Federal courts the power to issue injunctions against decisions of public utility commissions. The public utility interests oppose the measure on the ground that capital from one state would hesitate to seek investment in public utilities in another if Federal authority were removed. A majority of the Committee is said to be opposed to the legislation.

A BILL PROVIDING for a national hydraulic laboratory to study flood control and river hydraulics in general has been introduced by Senator Ransdell, of Louisiana. This action was taken at the suggestion of John R. Freeman, president of the American Society of Civil Engineers. It has long since been apparent that the scientific side of river hydraulics has not kept pace with the research and experimentation which has accompanied other branches of engineering.

SECRETARY HOOVER has expressed the opinion that the decision of the Supreme Court in the case of

Wyoming vs. Colorado in the matter of appropriation of water is of the greatest significance. The decision, in effect, wipes away state lines and gives those who first appropriate water rights full priorities regardless of where the water may have originated. This decision is against the State of Colorado which contends that it has the right to reserve for its own use water originating within the state. The decision is of great advantage to the lower portion of the Colorado basin, which is in a position to utilize water more promptly than is the upper portion of the basin. The decision will probably stimulate greatly the appropriation of water so that the priorities may be enjoyed. Secretary Hoover says that the decision will greatly simplify the work of the Colorado River Commission of which he is chairman.

JOSEPH HARRINGTON has recently been engaged as advisory engineer for the United Machine & Manufacturing Co., which now manufactures the Harrington traveling grate stoker.

THE SANFORD RILEY STOKER CO. of Worcester, Mass., has merged its interests with the Underfeed Stoker Co. of America and the companies allied to it. Products of the combined companies, including the Jones, Riley and Murphy stokers, will be manufactured in large part at Detroit, Mich., and at Worcester, Mass.

R. Sanford Riley becomes president of the combined companies, F. H. Daniels, vice-president, and S. A. Armstrong, vice-president and managing director of the Underfeed Stoker Co. of America. The allied companies taken into the merger are A. W. Cash Co. of Decatur, Ill.; Craig Damper Regulator Co. of Detroit, and the Underfeed Stoker Co., Ltd., of Canada.

THE WESTERN LIGHT and Power Co. serves the city of Loveland, Colo., with electric light and power, but for some time past there has been a clamor for a municipal owned hydroelectric plant to be located on the Big Thompson River in Loveland Canyon. Now the city council has passed an ordinance instructing the mayor to advertise for bids for constructing the municipal plant, said bill passed providing for the sale of bonds not to exceed $425,000.

The bonds are to be in two issues, one by a general obligation bond and the other a light investment bond, the 6 per cent bonds to be retired annually over a period of 15 yr.

THREE IMPORTANT contracts to supply current for lighting and motors in buildings have recently been secured by the Commonwealth-Edison Co., of Chicago. They are for the Federal Reserve Bank Building, the Illinois Merchants' Bank Building and the Union Station Railroad Terminal. The first mentioned building is approaching completion, the second well under way, and the third has considerable ground work done. For the Union Station, current will be bought in bulk at 12,000 volts a.c., and transformed and distributed by the Chicago Union Station Co. It is estimated that 18,000,000 kw.-hr. will be used a year.

PENNSYLVANIA PUMP & COMPRESSOR CO. has recently opened a direct district office at 105 West Monroe St., Chicago, Ill., with H. M. Montgomery in charge.

ANSON W. BURCHARD, vice-chairman of the board of directors of the General Electric Co., has been elected president and chairman of the board of the International General Electric Company, succeeding Gerard Swope, its former president, who was recently chosen president of the General Electric Co., and Charles Neave, former chairman of the International General Electric Co., who has resigned.

DWIGHT P. ROBINSON & CO., engineers of New York City, has recently made a contract for group life insurance of its employes under which all individuals are provided life and disability insurance, increasing with the length of employment, the expense being borne by the company. Visiting nurses are provided by the insurance company in case of illness, and precautions taken for disease prevention.

THE BUSINESS of the Pittsburgh High Voltage Insulator Company will be carried on in the future under the name of the Westinghouse High Voltage Insulator Co., according to announcement made by C. M. Semler, general manager. The change in name, which was made by vote of the company's stockholders, does not affect the management or method of conducting the business of the company, which will be carried on as it has been in the past, according to the announcement.

THE COLORADO public utilities commission refused to grant a rehearing to the Colorado Power Co., the purpose of the power concern being to secure permission to increase its rates for current consumption. It has been only a short time since the commission went fully into the case and ruled that an increment was not justifiable.

IN ORDER that the stockholders may be more fully acquainted with the property in which they have ownership, the Commonwealth Edison Co., of Chicago, has recently issued a Year Book for 1922. The story of this company's growth is remarkable and the service it renders day by day is vital and interesting. The booklet contains a condensed record outlining, not only the company's growth and the service it renders, but also giving some inklings of expectations.

Ninety-two per cent of the 24,571 stockholders in the company are residents of Chicago and a little more than 4 per cent of them live in Illinois outside of the city. Upwards of one out of every three persons employed by the company own stock in the property. Last year the company did $37,139,830.64 worth of business, an increase of $2,000,000 over the previous year.

In the 8 great generating stations, the 62 substations, the thousands of miles of underground and overhead electric cables and other property owned by the company, there is invested $118,275,716.09. The total assets amount to $152,035,420.70.

The 2,140,247 tons of coal which were burned last year, produced 1,928,271,940 kw.-hr. of electrical energy. The increased efficiency of the equipment which generated this energy is reflected in the fact that although the energy sent out in 1921 was 44,702,000 kw.-hr. more than in 1920, the amount of coal consumed was less.

The statistical information contained in the book is of value, not only to stockholders of the company, but to others, as well, and is presented in an interesting manner. The fact that the energy output last year would keep a 60-w. lamp lighted continuously for 32,137,865,666 hr., may not be of particular value, yet these figures are not devoid of interest.